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Vegetation on Semi-Arid Rangelands, Cheyenne River Basin, Wyoming

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Abstract

Vegetation in the semi-arid rangelands in the Cheyenne River Basin in northeastern Wyoming, was classified by numerical cluster analysis of a dissimilarity matrix based upon vegetation attributes of 158 sample stands. Twenty-two vegetation types, their associated soils as well as the general habitat are described. The vegetation types provide a frame of reference and guidance for range and wildlife habitat management and for the rehabilitation of surface mined lands of the vicinity.

Key words: vegetation classification, cluster analysis, plant ecology, northeastern Wyoming, Cheyenne River Basin, vegetation types, soils, rangeland habitats

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INTRODUCTION

Quantitative descriptions of plant communities in the Cheyenne River Basin of Wyoming are lacking. Early investigations were largely taxonomic descriptions. Literature dealing with soils of the region are also limited. Private ownership of much of the land, coupled with low productivity and low surface economic value, plus the generally remote and inaccessible location, restricted ecological studies of the Basin until the mineral development of the 1970's. Detailed knowledge of the nature, extent, and distribution of the surface ecosystems specific to the area were unavailable. This information is needed both to plan the management of the traditional uses of surface resources and to provide guidelines for the revegetation of lands disturbed by surface mining.

This study examined the vegetation and soil characteristics of various plant communities of a portion of the Cheyenne River Basin in northeastern Wyoming. These communities represent the residual vegetation after years of grazing and other land uses. Cluster analysis was used to quantitatively characterize the plant communities with respect to their physiognomic character and associated soil properties.

Livestock ranching and associated supporting occupations dominated the economy of the Cheyenne River Basin before the early 1970's. The harsh environment limits forage production and, consequently, the economic value of the rangelands. At somewhat shallow depth beneath these rangelands is one of the largest coal reserves (approximately 0.9 trillion ton) in the United States (Thilenius and Glass 1974). The existence of this coal reserve is well-known and small-scale coal mines operations have been in operation for many years. The energy crisis of the mid–1970's stimulated large-scale surface mining of the coal. This commenced in the latter part of the decade and continues (at a somewhat reduced rate) now.

PREVIOUS STUDIES

The rangeland vegetation of northeastern Wyoming has been described by several authors who were concerned primarily with the description of vegetation at the formation level from extrapolation and interpretation, as well as identifying the capabilities of the land for crop production (Cary 1917; Dice 1943; Merriam 1898; Shantz 1911, 1923, 1924; Shantz and Zon 1923; and Shreve 1917).

Clements (1936) included all northeastern Wyoming in the area occupied by the *Stipa-Agropyron-Buchloe* faciation of the mixed-prairie grassland climax association. Weaver and Albertson (1956) indicated *Carex filifolia* and *Carex eleocharis* replaced Buchloe in mixed-prairie in Wyoming, north of the North Platte River. Both publications had *Bouteloua gracilis* as the characteristic species of mixed-prairie grassland in this area and *Agropyron smithii, Stipa comata, Poa secunda* and *Koeleria cristata* as important associated grasses. Beetle (1950) recognized *Buchloe dactyloides* as a native of the shortgrass prairie. Costello (1944) considered the shortgrass prairie equivalent to the mixed-prairie of Clements and Shelford (1939). Carpenter (1940) listed 18 different designations for the shortgrass prairie, showing the lack of agreement among ecologists. He designated the same fasciation as *Bouteloua-Bulbilis* association, with its major fasciations and consociations of which the *Bouteloua* formation of Shantz (1906) is most common. Allred (1941), Clements (1936) and Weaver et. all (1956) considered shrubs to be seral components of the mixed-prairie climax, generally present on overgrazed range sites.

Costello (1944) classed *Artemisia tridentata/ Bouteloua gracilis-Agropyron smithii* shrubland in this region as a distinct vegetation type, representing "a broad transition between the sagebrush and shortgrass which passes in a north-south direction through the east-central portion of the state [Wyoming]." He also described shrubland dominated by *Atriplex confertifolia* on saline substrates, and by *Sarcobatus vermiculatus* on alkali substrates as climax vegetation in the Northern Great Plains. Both were considered examples of southwestern semi-desert shrubland vegetation that extended into the Northern Great Plains where soils had high content of basic miner-

als. He also considered a second major type dominated by *Distichlis stricta*, common to dry alkaline swales and meadows. Jameson (1952) also described shrubland vegetation dominated by these same species as present in northeastern Wyoming. *Atriplex canescens* and Krascheninnikovia (formerly *Eurotia* and *Ceratoides*) also were prevalent shrubs.

Woolfolk (1949) described four shrubland types on rangeland in Montana, adjacent to northeastern Wyoming. *Artemisia tridentata/Bouteloua gracilis* shrubland occurred in rolling topography on well-drained sites with clay-loam textured soils that remained moist well into the growing season. *Artemisia cana/Agropyron smithii* shrubland was present on gently rolling floodplains with clayey, alkaline soils. *Rhus trilobata-Yucca glauca* shrubland was found on moderately steep terrain with sandy to gravelly soils that had high water absorption capacity and low runoff. *Sarcobatus vermiculatus-Atriplex confertifolia-Agropyron smithii-Agropyron spicatum* shrubland occupied rough terrain with sometimes rocky, very clayey, frequently alkaline, soils that had low water absorption capacity and high runoff.

Kuchler's (1964) 1:3,160,000 scale map of potential (climax) vegetation types of the conterminous United States shows seven vegetation types in or next to the Cheyenne River Basin:

Type 16. Eastern ponderosa pine forest (*Pinus ponderosa*);
Type 17. Black Hill's ponderosa pine forest (*Pinus ponderosa*);
Type 18. Ponderosa pine-Douglas fir forest (*Pinus ponderosa-Pseudotsuga menziesii*);
Type 55. Sagebrush steppe (*Artemisia tridentata-Agropyron spicatum*);
Type 56. Wheatgrass-needlegrass shrub steppe (*Agropyron smithii-Stipa comata/Artemisia tridentata*);
Type 64. Grama-needlegrass-wheatgrass grassland (*Bouteloua gracilis-Stipa comata-Agropyron smithii*);
Type 66. Wheatgrass-needlegrass grassland (*Agropyron smithii-Stipa comata*).

The scale of the map makes it impossible to show accurately the presence of all the vegetation types in the Cheyenne River Basin. The Bureau of Land Management published three reports on land planning and classification of public domain lands in northeastern Wyoming: Powder River Basin (USDI 1956); Upper Cheyenne River Basin (USDI 1957a); Belle Fourche River Basin (USDI 1957b). The first two reports included color-coded maps (1:250,000 scale) of vegetation, land capability, soil erosion, and livestock carrying capacity. The Belle Fourche River Basin Report did not contain comparable maps. Lands administered as National Grassland and the large areas of private land were not included. Greater detail of taxa composition was provided in the Environmental Impact Statement for the Eastern Powder River Coal Basin (USDI 1974).

Lang (1973) defined four generalized natural range types in the Cheyenne River Basin based on the dominant plants: sagebrush (*Artemisia tridentata*); shortgrass-sagebrush (*Bouteloua gracilis -Artemisia tridentata*); mixed grass (*Bouteloua gracilis-Agropyron smithii-Stipa comata-Koeleria cristata*); cactus (*Opuntia polycantha*); and one artificial range type, abandoned farmland, dominated by *Artemisia tridentata*.

A range site classification for the 25–35 cm (10–14 inch) precipitation zone of northeastern Wyoming was published by the USDA Soil Conservation Service (no date). Soils and physical sites were emphasized. Vegetation was described with an estimated abundance scale for the most common species in each soil-mapping unit. Most vegetation types were covered by this technique, but classification was not attempted.

Six subjectively defined types of vegetation were recognized in the final environmental impact statement for the 1086-ha coal mine site of the North Antelope Mine (Office of Surface Mining Reclamation and Enforcement 1982). These were: breaks grassland, greasewood grassland, meadow grassland, playa grassland, scoria grassland, and upland grassland. A map (60 mm = 1.62 km scale) of vegetation and associated major soil associations was provided, but information on species composition, importance, and abundance was not included in the report. Average plant coverage, standing crop, and shrub density of the vegetation was given.

PHYSICAL SETTING OF THE CHEYENNE RIVER BASIN

Geology

Surface bedrock in the Cheyenne River Basin is of sedimentary origin (Breckenridge et al. 1974). Exposed rocks are sandstones, shales, conglomerates, and coals of the Tertiary age Wasatch (on the west) and Fort Union (on the east) formations. The contact

of these two formations is exposed in the Rochelle Hills escarpment (see below). A north-south oriented, more or less continuous band of reddish brown-colored "clinker" beds (locally called "scoria") occurs along the contact. This material develops where heat and gases from burning coal seams first melt then partially fuse and bake overlying sandstones and shales. Clinker material resists erosion and caps buttes and the escarpment. The character of the clinker ranges from dense and glassy to porous and vesicular. Quaternary to recent age, unconsolidated alluvial deposits are present in the channels of the major creeks and the Cheyenne River. Wind-blown sand dunes occur in the southwestern part of the basin.

Substrates

Residual soils predominate over the entire area (Breckenridge et al. 1974). Surface horizons are light colored and low in organic matter. Subsoils are normally light brown or reddish brown and may contain carbonates. On gently rolling uplands, a slightly altered bedrock (C horizon) is usually not more than 1 m below the surface; on more rolling terrain, depth to bedrock is 0.5-0.8 m; and on steep slopes only a few centimeters of soil or soil material overlies bedrock. Rock outcrops are common on the steepest slopes. Soil depths in alluvial deposits or wind-blown sand exceed 1 meter. Alluvial soils contain varying quantities of soluble calcium, sodium and magnesium salts. Soil texture usually reflects the character of the bedrock. Sandy and medium-textured friable soils are underlain by sandstone and shale, and heavy clay soils by clayey shale. Soils developed from scoria are brown or reddish brown color, medium-textured, shallow, gravelly, and rocky. The soils of the area are primarily of the orders of Aridisols and Entisols, with representative groups such as Haplargids, Paleargids, Torrifluvents, and Torriorthents (Glassey 1955, Kee 1990, Reckner 1988,). Ustollic Haplargids, Ustollic Paleargids and Ustic Torriorthents are major soil groups and comprise more than 75% of the total area. These soils are generally shallow to deep, well-drained residuum and characteristic of ridges, toe slopes, foot slopes, and scarps common to the rough broken landscape. Ustic Torrifluvents and Typic Fluvaquents are most prevalent along low stream terraces and floodplains, e.g., Black Thunder Creek. The fluvent group are generally deep, well-drained and derived from alluvium; whereas the aquents are deep and poorly drained. Aeric Haplaquepts, a minor component of about 1% of the total area, are characteristic of wetland environments such as playas and lakebeds. Typic Haplaquepts are characteristic of saline sites with greasewood and saltgrass vegetation.

Physiography

The Cheyenne River Basin is located in the unglaciated section of the Missouri Plateau (Breckenridge et al. 1974). The present physiography is the result of recent erosion cutting into the rocks that now occupy the surface, and of folding, faulting, and subsidence. Four north-south oriented physiographic subregions are present: the *Dissected Upland* in the west has moderately steep local relief with large areas of badlands and flat-topped hills; the *Rolling Divide* in the central portion has smoother topography with moderate local relief except for scattered, flat-topped red scoria buttes 10- 30 m high; the 90–120 m high, east-facing *Rochelle Hills Escarpment* forms the eastern edge of the rolling divide; the *Eastward-sloping Plain* has topography similar to the Rolling Divide and extends east to the base of the Black Hills in South Dakota. Elevations range from 1830 meters along the western watershed to 1100 meters where the Cheyenne River crosses into South Dakota. Most of the basin is between 1340 and 1520 meters elevation. The peripheral watershed is poorly defined, except in the Dissected Uplands, and has long rounded ridges and rolling plains. Major streams have dendritic drainage patterns; tributaries have parallel drainage patterns. Most streams are only moderately entrenched and have intermittent flow over most of their length. The valley of the Cheyenne River is over 9 km wide in its lower reaches. Flow is mainly subsurface, with occasional shallow pools. Flash floods often occur with summer thunder showers.

Climate

The Cheyenne River Basin has a middle latitude steppe climate and is semi-arid with great annual temperature variation between summer and winter (USDI 1974). The climate is somewhat cool, with January the coldest month. Average daily winter minimum temperatures range from –15° to 0.5°C. Temperatures below –18°C are common from December to February. Summer temperatures will exceed 38°C for short periods in July and August. The mean July maximum is 32°C. Maximum precipitation occurs in spring and early summer. Most of the basin

receives between 25 and 35 cm of total precipitation a year. Midsummer precipitation is usually light and drought conditions are common. Thunder and hailstorms with consequent high and rapid runoff occur during the summer. The record 24-hour storm precipitation for Wyoming (13.97 cm) was recorded in the basin. Snow is common from December to May and several snowfalls exceeding 20 cm will occur in a typical year. Strong winds frequently accompany winter storms and snowdrifts exceeding several meters in depth can form. Blizzard conditions usually do not last more than a few hours. Average wind velocities are from 12 to 19 km per hour, but winds often reach 48 to 64 km per hour, especially from November to March. The average relative humidity is low (ca 25–30%). Annual range in precipitation-evaporation budget is –24 cm to 31 cm. Sunshine ranges from 55% in winter to over 75% in summer. Average daily solar radiation exceeds 700 langleys because of somewhat high elevation and clear atmosphere.

Natural Resources and Land Use

The Cheyenne River Basin occupies approximately 12,300 km^2 of rangeland in Campbell, Converse, and Weston Counties in the northeastern corner of Wyoming. Almost 80% of the land is privately owned (USDI 1974). Publicly owned lands are administered by the USDA Forest Service and the USDI Bureau of Land Management as the Thunder Basin National Grassland. Private and public lands are side by side in a complex pattern of ownership: legal boundaries between public and private land frequently are not surveyed and surveyed boundaries are often unmarked. Important natural resources in the area are minerals (such as coal, uranium, oil and gas, bentonite) and soil and rangeland vegetation. Oil and gas production and exploration have been a major development activity since discovery of the Osage Oil Field in 1918. Numerous oil and gas fields are scattered throughout the Basin. Raw and refined petroleum products are transported out of the area via truck and pipeline. Coal mines have been in operation since the early 1900's. One of the largest coal reserves (approximately 0.9 trillion tonne) in the United States is found beneath surface soils (Thilenius and Glass 1974). The existence of this coal reserve was long known, but the energy crisis of the mid–1970's stimulated large scale surface mining of the coal. This commenced in the latter part of the decade and continues on a reduced scale today. Uranium mining is another major land use of the Cheyenne and Powder River Basins.

Cattle and sheep grazing remains the dominant land use in the area despite inherent low forage production capacities. Estimated average carrying capacities range near 33 acres per cow for 12 months (Glassey 1955). Many ranching operations have augmented forage production through crested wheatgrass pastures (Reckner 1988). The Thunder Basin National Grasslands is presently grazed by about 40,000 cattle and sheep. Many ranches are dependent on grazing on public lands (BLM, Forest Service, and state) which constitute about one-third of the total area (Kee 1990, Reckner 1988). Prime agricultural farmland comprises about 1% of the total area.

STUDY AREA

The study area represents about one-fourth of the Cheyenne River Basin and was chosen because of the importance of the region to development of surface coal mining. The area is approximately 2800 km^2 and surrounds the junction of Campbell, Converse and Weston Counties, Wyoming. Most of the drainages of the major tributaries of the Cheyenne River (Dry Fork Cheyenne River, Black Thunder Creek, Little Thunder Creek, Antelope Creek, Pine Creek, Porcupine Creek, and Wildcat Creek) were included. Much of the area is within the boundaries of the Thunder Basin National Grassland (fig. 1). The four physiographic subregions are present and provide a diversity of geological, topographical, and edaphic features. The study area is also the area of the most intensive development of surface coal mining in the Cheyenne River Basin. All the common and limited vegetation types observed in the reconnaissance were present in this area.

METHODS

Reconnaissance Survey

A preliminary aerial reconnaissance was made of the entire Cheyenne River Basin to assess general variability in vegetation and landscape. An attempt was made to survey most of the area from the available road system. Some large areas of privately owned land were examined only from the air.

Ground reconnaissance relied on visual recognition of spatially repeated assemblages of plants with similar structure, stratification, characteristic lifeforms and taxa, and the relationship of these plant assemblages to physical site and edaphic features.

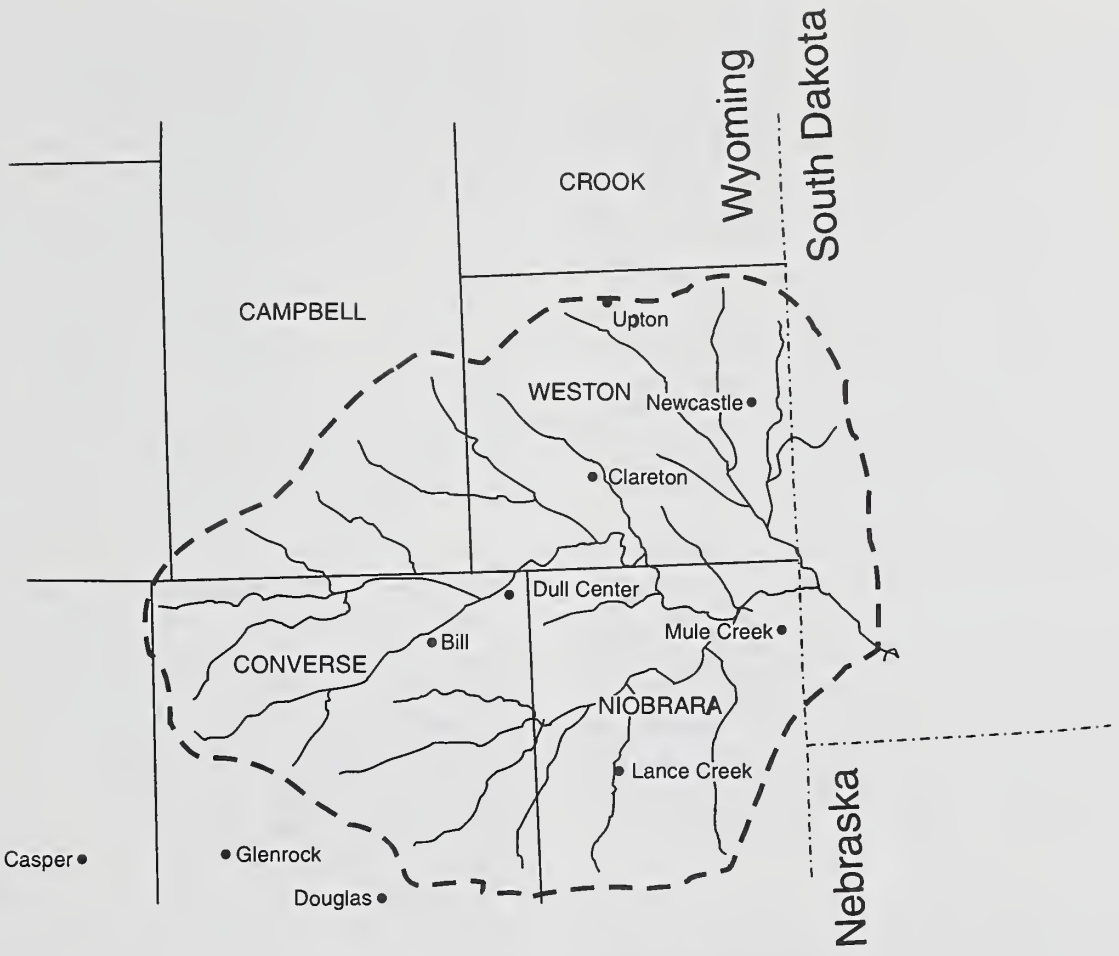

Figure 1. Cheyenne River Basin study area.

Only plant specimens collected for taxonomic identification were removed. The importance of each species in each stratum of the vegetation was subjectively estimated on a 5-class scale: 5 = dominant, 4 = codominant, 3 = common, 2 = present, 1 = rare. Geological (from available maps), physiographic, and surface soil features, and estimated moisture regime were recorded. The presence of wildlife, and past and current human uses, especially livestock grazing, farming, and rangeland revegetation were noted. The locations of the sites examined were recorded on maps (2.54 cm = 1.61 km scale).

The life form and growth habit of the dominant and codominant species in each stratum were used to characterize the vegetation. Logical division was used for categorization. Initial division was on the presence of a well- defined stratum of woody vegetation. If this were present, a second division was made based on the height of the mature individual: woody vegetation at least 4 m tall when mature was defined as trees; other woody vegetation as shrubs. Trees were further subdivided on leaf shape (needleleaf, broadleaf) and leaf retention in winter (evergreen, deciduous). All shrubs were deciduous and were subdivided based on height at maturity. Shrubs less than 0.5 m tall when mature were called dwarf-shrubs. The term "shrub" was used to characterize vegetation when herbs were not abundant beneath the shrub canopy; when herbaceous plants were abundant, the term "shrub-steppe" was used. Grasses were the prevalent herbs, although forbs (including cacti) were often abundant and a few shrubs were present in most types of herbaceous vegetation. These shrubs were usually either poorly developed, or widely scattered. Herbaceous vegetation was subdivided based on the growth habit of the grasses (sodgrass or bunchgrass) and the apparent moisture regime of the immediate site; hydric and mesic sites were separated from xeric sites. All xeric grassland vegetation was designated steppe. Some hydric/

mesic vegetation types were dominated by graminoids (sedges, spike-rushes).

The relative importance of vegetation types was estimated on the basis of areal extent and distribution within the Cheyenne River Basin. "Common" indicated a vegetation type present in many geographical locations and covering large areas of the land surface where it was present. "Limited" vegetation types were those that were less frequently repeated spatially, or occupied specialized habitats. A "rare" vegetation type either was: present only at one geographic location in the Cheyenne River Basin, or located on the periphery of the Cheyenne River Basin. The latter may have been common outside the Cheyenne River Basin.

Big sagebrush was identified only to a species level at the time the study was conducted. However, according to "Sagebrush in Wyoming" (Beetle and Johnson 1982), the only subspecies of *Artemisia tridentata* that occurs within the Cheyenne River Basin is Wyoming big sagebrush (*Artemisia tridentata wyomingensis*). The subspecies name is not used in the text or in the tables to be consistent with the level of taxonomic identification at the time the study was conducted.

Sample Site Selection

The 158 sites selected for intensive sampling were chosen from the array of locations visited during reconnaissance. Each had an example of a subjectively predetermined vegetation type of either common or limited importance. Some apparently rare vegetation types were not sampled because multiple samples could not be obtained. Locations evidently burned recently or heavily grazed by livestock were excluded. Locations that received moderate grazing by livestock and grazing by wild herbivores, such as pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), wapiti (*Cervus canadensis*), and blacktailed jackrabbit (*Lepus americanus*) were not excluded from sampling.

Field Sample Design

The field sample unit was an 8 m by 20 m macroplot. This was subdivided into 10, 4 m^2 subplots to sample overstory tree density (1.0 dm basal diameter classes). Density and frequency of shrub taxa over 1.0 dm in height were determined on a belt transect of 20, contiguous, 1.0 quadrats located along the centerline of the macroplot. Five height classes were used: 1–2 dm; 2–5 dm; 5–10 dm; 1–2 m; >2 m. Canopy coverage (Daubenmire 1959) and frequency of trees and shrubs under 1.0 dm tall (seedlings), grasses, graminoids, forbs (including cacti), soil cryptogams (as a group), plant litter (including attached dead plant material), bare soil, gravel (1–20 mm diameter), and stones and rocks (>20 mm diameter) were estimated on 40, 0.1 m^2 quadrats located at 0.5 m intervals on a belt transect along the centerline of the macroplot. Mean values were used in analysis.

Samples of the first three surface soil horizons were collected to determine Ph (glass electrode, 1:2.5 soil water solution) soil texture (hydrometer) and calcium and sodium content (atomic absorption). Aspect of slope (degrees from true north), angle of slope (%), and location on slope (lower 1/3, mid 1/3, upper 1/3) were used to describe the physical site.

Analytical Procedures

Vegetation types identified during the reconnaissance were further refined by using a hierarchical classification approach using cluster analyses (Clifford and Stephenson 1975). This process mathematically links individual plots into groups on the basis of shared descriptive attributes. The result is a dendrogram showing the relative degree of relationship amongst and between stands of vegetation.

Descriptive attributes were: average density of tree and shrub species by diameter class; average percent canopy coverage of shrub, grass, graminoid, forb species; and average percent ground cover of cryptogams, litter, bare ground, and coarse fragments. Each attribute value was standardized using a maximum equals 1.0 row-column transformation.

Ward's Method polythetic cluster analysis (Wishart 1975) was used to establish an initial numerical relationship of the sample sites. The result of cluster analysis was displayed in a two-dimensional dendrogram (fig. 2). Preliminary clusters were recognized at a level that produced the minimum number of one and two stand clusters. Average values of all attributes were calculated to describe each cluster.

Iterative multiple discriminate analysis (Klecka 1975) was used to determine the proportion of misclassified stands and to relocate misclassified stands into the correct cluster. Iteration was continued until 100% correct classification was obtained.

Within-cluster average values of the descriptive attributes of all revised clusters were calculated and used to describe a model stand which represented the cluster. Program SIMID (Volland and Connelly 1978) was used to calculate a matrix of percentage similarity between all pairs of model stands using

the Czekanowski coefficient (Goodall 1978). The matrix of percentage similarity was the input for a second hierarchical cluster analysis based upon the average linkage between groups (Volland and Connelly 1978). The relationships of the final set of clusters are displayed in figure 2.

Nomenclature

The term "vegetation type" (Whittaker 1978) is used to indicate they are abstract synecological units developed from descriptive attributes measured or estimated on a finite set of real stands. The vegetation types were named after the species in each stratum of the vegetation with the greatest mean density or canopy coverage and the highest constancy. These are the characteristic species. Tree, shrub, and herb strata were recognized, but all three were not always present.

Vegetation types are represented by acronyms using the first two letters of the genus and species names of plants. Codominant species are separated by a dash (-). Overstory/ understory dominants are separated by a virgule (/). For example, ARTR/ BOGR-AGSM translates as Artemisia tridentata/ Bouteloua gracilis-Agropyron smithii or, in common name, Big Sage overstory with a blue grama and western wheatgrass understory. The nomenclature in this paper follows Harrington (1954) with the exception of *Schizachyrium scoparium*.

Each of the 22 vegetation types is illustrated with a representative photograph, a brief narrative description, and tabular summaries of the site, substrate, and vegetation. Species names were not provided for plants with trace cover values and they are combined and listed as "other" in the tables. A list of all vascular plant species included in the 22 vegetation types is given in the appendix.

RESULTS AND DISCUSSION

Preliminary Classification

The preliminary classification of the vegetation types of the Cheyenne River Basin determined from the reconnaissance survey is outlined below.

FOREST VEGETATION TYPES (TREE STRATUM MORE THAN 4 M TALL AT MATURITY)

Overstory evergreen-needleleaf trees

Pinus ponderosa/Juniperus scopulorum: sandstone-scoria, Rochelle Hills Escarpment, mesic sites, common.

Pinus ponderosa/Artemisia tridentata/Agropyron spicatum: sandstone-scoria, Rochelle Hills Escarpment, xeric sites, common.

Pinus ponderosa/Agropyron spicatum: sandstone, Pine Ridge Hogback only, extreme western watershed, rare.

Pinus ponderosa/Schizachyrium scoparium: shale, Black Hills foothills, rare.

Pinus ponderosa/Stipa viridula: sandstone, Hat Creek Rim only, southern watershed, rare.

Juniperus scopulorum/Agropyron spicatum: shale, steep slopes Rochelle Hills Escarpment, limited.

Juniperus scopulorum/Calamovilfa longifolia: coarse alluvium, stream channels, base Rochelle Hills Escarpment, limited.

Pinus flexilis/Rubus deliciosus: rocky, Pumpkin Buttes summit only, rare.

Overstory broadleaf-deciduous trees

Populus sargentii/Symphoricarpos occidentalis/ Agropyron smithii: alluvial floodplains of larger rivers, common.

Populus sargentii/Symphoricarpos occidentalis/ Smilacina stellata: alluvial floodplains of larger rivers; ungrazed sites; rare.

SHRUB VEGETATION TYPES (HERB STRATUM POORLY DEVELOPED, SHRUB STRATUM LESS THAN 2 M TALL)

Xeric sites

Cercocarpus montanus/Yucca glauca: rocky, Black Hills foothills, rare.

Mesic or hydric sites

Crataegus erythropoda-Prunus virginiana: mesic upland draws, extreme northwest, rare.

Prunus virginiana: spring seeps, Rochelle Hills Escarpment, rare.

Salix interior: gravel and sand bars, major rivers, rare.

SHRUB-STEPPE VEGETATION TYPES (HERB STRATUM WELL-DEVELOPED, SHRUB STRATUM GREATER THAN 2 M TALL)

Vegetation types on well-drained substrates

Artemisia tridentata/Bouteloua gracilis-Stipa comata: loamy uplands, throughout Cheyenne River Basin, common.

Artemisia tridentata / Bouteloua gracilis-Agropyron smithii: clayey uplands, throughout Cheyenne River Basin, common.

Artemisia tridentata / Agropyron spicatum: rocky, scoria buttes, Rochelle Hills Escarpment, limited.

Artemisia tridentata / Schizachyrium scoparium: rocky, northeastern Cheyenne River Basin, rare.

Artemisia cana / Agropyron smithii: alluvium, nonsaline-alkali floodplains, common.

Artemisia cana / Calamovilfa longifolia: stabilized sand dunes, limited.

Artemisia cana / Ceratoides lanata-Stipa comata: sandy uplands, Eastward-sloping Plain only, limited.

Rhus trilobata / Agropyron spicatum: scoria-sandstone buttes and ridges, limited.

Yucca glauca / Calamovilfa longifolia: stabilized sand dunes and sandstone outcrops, limited.

Symphoricarpos occidentalis / Agropyron smithii: nonsaline-alkali floodplains, limited.

Symphoricarpos occidentalis / Smilicina stellata: ungrazed nonsaline-alkali floodplains, rare.

Symphoricarpos occidentalis / Poa sp.: mesic upland draws, rare.

Mineralized substrates

Sarcobatus vermiculatus / Distichilis stricta: saline-alkali, well-drained floodplains, limited.

Sarcobatus vermiculatus / Agropyron smithii: colluvial scoria over shale, steep lower slopes, Rochelle Hills Escarpment, rare.

Sarcobatus vermiculatus / Atriplex gardneri: shale uplands, Eastward sloping plains, rare.

Artemisia pedatifida / Agropyron smithii: saline-alkali uplands, impeded drainage, Rolling Divide, limited.

Atriplex canescens / Sitanion hystrix: saline shale uplands, extreme northern Cheyenne River Basin, rare.

Atriplex canescens / Schizachyrium scoparium: bentonite outcrops, extreme eastern Cheyenne River Basin, rare.

HERBACEOUS VEGETATION TYPES (SHRUBS MISSING OR NOT ABUNDANT)

Mesic or hydric sites

Agropyron smithii: seasonally flooded playas, common.

Elymus cinerus: swells and seeps; Pumpkin Buttes only, rare.

Carex nebraskensis: hydric riparian meadows, rare.

Spartina pectinata-Deschampsia caespitosa: mesic riparian meadows, rare.

Eleocharis macrostachya-Eleocharis acicularis-Alopecurus carolinianus: continuously flooded playas, rare.

Distichilis stricta-Agropyron smithii: saline-alkali floodplains, rare.

Xeric sodgrass steppe

Bouteloua gracilis-Stipa comata: sandy to sandy-loam, level to rolling uplands, throughout eastern Cheyenne River Basin, common.

Bouteloua gracilis-Agropyron smithii: loam to clay-loam, level to rolling uplands, throughout eastern Cheyenne River Basin, common.

Bouteloua gracilis-Agropyron spicatum: stony, gently rolling upland ridges, west of Rochelle Hills Escarpment, limited.

Xeric bunchgrass steppe

Agropyron spicatum: rocky outcrops, Rochelle Hills Escarpment and scoria buttes, limited.

Schizachyrium scoparium / Bouteloua gracilis: sandy to stony uplands, Rochelle Hills Escarpment, limited.

Schizachyrium scoparium: blowouts, sandy badlands, eastward-sloping Plain, rare.

Calamovilfa longifolia-Stipa comata: stabilized sand dunes, eastern Cheyenne River Basin, limited.

Carex filifolia-Bouteloua gracilis: sandstone outcrops, eastward-sloping Plain, limited.

Relatively few species were classed dominant when specialized habitats such as riparian, wetland, or unique geological formations were omitted. Two trees (*Pinus ponderosa, Juniperus scopulorum*); four shrubs (*Artemisia tridentata, Artemisia cana, Sarcobatus vermiculatus, Rhus trilobata*); and seven graminoids (*Bouteloua gracilis, Agropyron smithii, Agropyron spicatum, Stipa comata, Schizachyrium scoparium, Calamovilfa longifolia, Carex filifolia*) were important as dominants in the various vegetation strata of the common vegetation types in semi-arid habitats. No forbs were considered dominant.

Artemisia tridentata and *Bouteloua gracilis* were almost everywhere on xeric uplands. The general impression obtained during the reconnaissance was that much of the rangeland vegetation could be classed as an *Artemisia tridentata / Bouteloua gracilis* vegetation type. This vegetation type was far from homoge-

neous. There was considerable variation both in the abundance of the shrub and herbaceous dominants and in the abundance and composition of the more common subordinate grasses. Relative abundance of the latter appeared to be related to the soil texture of the substrate. Substrate texture seemed a reasonably good index of composition and abundance of subordinate species. It is, of course, a complex variable, and affects many functional attributes such as infiltration, water-holding capacity, root penetration, etc.

Fine textured (clayey) substrates had *Agropyron smithii* as a codominant in the herbaceous stratum. Moderately coarse substrates (silty to sandy loams) had *Stipa comata* in greater abundance. *Stipa comata* was also present on sandy soils where other grasses such as *Calamovilfa longifolia* and the sedge *Carex filifolia* became more abundant. *Artemisia tridentata* was the abundant shrub on both fine and moderately coarse substrates, but *Artemisia cana* replaced it on sandy substrates, particularly where there was seasonal flooding or natural subirrigation. *Artemisia tridentata* was present, but not especially abundant in exposed locations with coarse textured soils on scoria buttes. In this situation, the bunchgrass *Agropyron spicatum* dominated or shared dominance of the herbaceous stratum with *Bouteloua gracilis*. Neither grass was abundant. *Schizachyrium scoparium* formed a distinct tussock grassland on stony uplands.

Artemisia tridentata and *Agropyron spicatum* also were present in the understory of woodlands with an openly distributed overstory. When the overstory tree canopy was closed, an understory was almost absent and cones and shed needles covered the ground.

Populus sargentii formed stands of deciduous woodland many hectares in extent on the floodplain in the lower reaches (in Wyoming) of the main Cheyenne River. It was found in narrow, fringing stands in the lower reaches of the major tributaries. All but one of the floodplain sites examined had been or were being used for livestock winter range. Grazing pressure was generally heavy to severe and the herb strata contained many exotic species. *Symphoricarpos occidentalis* usually formed a moderately dense shrub strata under the tree canopy. It was often heavily browsed. The ungrazed site had a lush understory with the forb *Smilicina stellata* as the herb stratum dominant.

One of the more rare and interesting vegetation types was the *Pinus flexilis* woodland on the summit of the Pumpkin Buttes. From a distance the expected vegetation type was *Pinus ponderosa* because of the towering dominance of this species over *Pinus flexilis* in the surrounding area. Isolated, stands of *Pinus flexilis* are present on similar sites at somewhat lower elevations from western North Dakota to northwestern Nebraska (Little 1971) and in the Black Hills of South Dakota (Thilenius 1970). Most of the other rare vegetation types were found in wetlands, which, indeed, are a rarity in the Cheyenne River Basin. Livestock are attracted to the green forage of these wetlands and all of the examples located were severely overgrazed.

Numerical Classification of Vegetation Types

Preliminary cluster analysis grouped the initial 158 stands into 30 clusters, with a subsequent analysis further reducing the clusters to 22. The similarity relationships of the 22 clusters developed by the numerical analysis are shown in figure 2 and are defined subjectively at the 48% level. At this level, field observations, the preliminary classification, and structural vegetative composition of individual stands fit best. Beyond this point, cluster analysis forms groups at levels above vegetation type criteria, e.g. substrates. Some stands are quite dissimilar as indicated by low similarity coefficients, e.g., POSA/SYOC or PIPO-JUSC.

Relationships Between Vegetation Types

The 22 vegetation types defined by numerical classification (fig 2) may be simplified into clusters which are internally more diverse and fewer in number. At the 48% Sorenson coefficient we have the lowest classification containing the 22 vegetation types called the first-level of classification. At 22% similarity level number of clusters are reduced to 9, called second-level. At the 10% similarity coefficient, a third level is formed where all 22 vegetation types are grouped into three clusters. The purpose of defining at lower levels is to find a level at which groups of stands can be defined relative to such synthetic labels as association or vegetation type.

The first cluster, second-level *Pinus ponderosa-Juniperus scopulorum* combines two of the three evergreen-needleleaf forest vegetation types. The two forest vegetation types have the greatest paired similarity. This is due to the understory vegetation because the characteristic species of the overstory are different, although both species do occur in both vegetation types. The *Schizachyrium scoparium* bunchgrass steppe vegetation type merges at a much lower

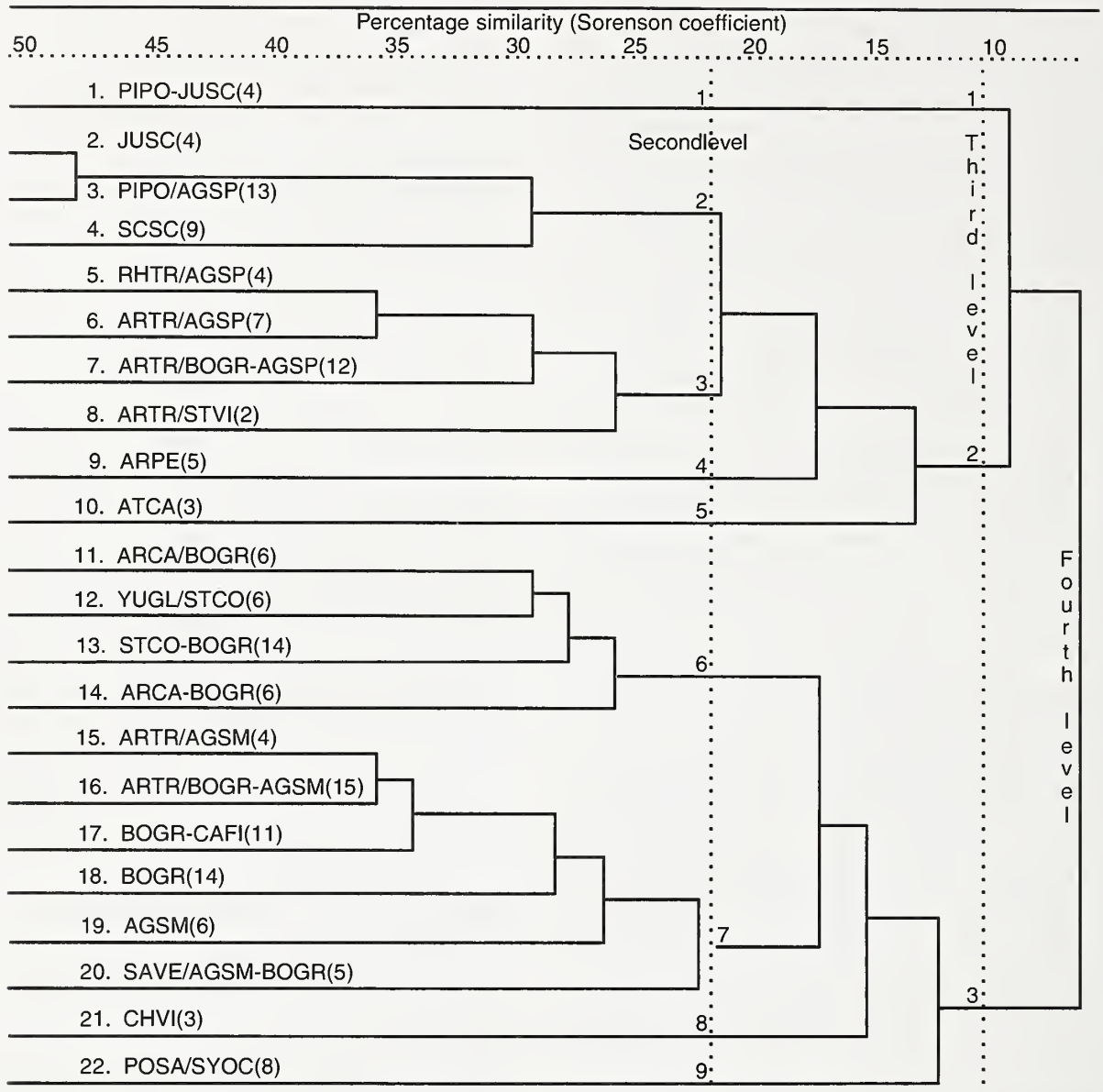

Figure 2. Similarity coefficient dendrogram of vegetation relationships in the Cheyenne River Basin. Linkage at coefficient = 48% best illustrates vegetation types based upon model characteristics. Linkage at 22% and 10% illustrates the relationships between vegetation types and their associated substrates, and vegetation types with landform, respectively. Number in ( ) represent total stands sampled (n).

level of similarity to form a three-unit group with an interesting combination of species with eastern and western floristic affinities. Dry, low elevation, *Pinus ponderosa* forest in the Black Hills of Wyoming and South Dakota and in the White River Badlands of western Nebraska have *Schizachyrium scoparium* as the characteristic understory species (Thilenius 1972). *Agropyron spicatum* is absent. A well-developed overstory of *Pinus ponderosa* did not occur in any of the sample stands where *Schizachyrium scoparium* was characteristic, but trees were often nearby. A forest habitat type (Daubenmire 1959) with a *Pinus ponderosa* overstory and an understory with *Agropyron spicatum* as the characteristic species is present in eastern Montana and this type of vegetation also is present in the Intermountain and Pacific Northwest regions (Pfister et. al. 1977). The most unifying physical site attributes are geographic location in the Rochelle Hills Escarpment and general abundance of coarse fragments of sandstone and scoria in the substrate.

The second cluster, second-level combines four vegetation types. All are shrub-steppe. The two most closely related vegetation types have *Artemisia tridentata* and *Agropyron spicatum* as characteristic, or

relatively abundant, subordinate species. The major difference is the presence of *Rhus trilobata* as the characteristic shrub. *Rhus trilobata* has a predominantly western distribution. The presence of these species gives a strong Great Basin character to the vegetation. The third vegetation type has *Bouteloua gracilis* cocharacteristic in the herbaceous stratum. All three of these vegetation types occur on uplands where the substrate has a relatively high content of coarse fragments in the upper part of the solum. *Stipa viridula* is the characteristic species of the herb stratum in the forth vegetation type. Both *Bouteloua gracilis* and *Stipa viridula* are species with predominantly Great Plains distributions and this second-level cluster also can be considered a transitional phytosociological unit between two major plant formations.

Clusters three, four and five, second-level do not combine any further at this level. The *Artemisia pedatifida*, and the *Atriplex canescens* vegetation types both are present on sites with unique substrates and represent distinctly different types of vegetation. Intuitively, the *Pinus ponderosa-Juniperus scopulorum* vegetation type would be included in the first cluster units described above, but the virtual absence of an herbaceous stratum made it numerically distinct from the other evergreen-needleleaf forest vegetation types and all the other vegetation types.

The sixth cluster, second-level includes four vegetation types which are typical of substrates with sand and sandy loam textures. These substrates are developed from recently deposited aeolian and alluvial materials and from sandstone. *Artemisia cana* and *Yucca glauca* are the characteristic shrubs; *Bouteloua gracilis*, *Stipa comata*, and *Calamovilfa longifolia* are the characteristic herbs.

The seventh cluster, second-level contains six vegetation types representative of Great Plains shrub-steppe and steppe vegetation which occupy level to rolling uplands and are the most widely distributed types of vegetation in the Cheyenne River Basin. *Artemisia tridentata* and *Sarcobatus vermiculatus* are characteristic shrubs. *Bouteloua gracilis*, *Agropyron smithii*, and *Carex filifolia* are the most common herbaceous plants. This vegetation is found throughout the Cheyenne River Basin on level to rolling terrain where the substrate tends to be medium-textured.

Clusters eight and nine, second-level also do not combine with any other first level clusters. They are different from the other second-level clusters and from each other. One is a vegetation type found on badlands terrain. *Chrysothamnus viscidiflorus* is the characteristic shrub and *Calamovilfa longifolia* is the most important understory species. This vegetation type is not common in the Cheyenne River Basin. The next type is *Populus sargentii* riparian woodland which occupies the alluvial floodplain and the lower reaches of the major tributaries of the Cheyenne River.

The 22 first level clusters are further grouped at a third-level with internal similarity of 10%. Because of the highly diverse nature of the 22 vegetation types it is not possible to designate any characteristic species. In general, it contains vegetation types of the transition between the Great Basin and Great Plains plant formations.

MANAGEMENT IMPLICATIONS

The significance of the information presented is in the quantitative definition of reference areas. The vegetation data is useful to resource managers as a guide to developing restoration plans for areas that have been impacted by surface mining, petroleum exploration or development, or other disturbance activity. Considerable details have been included in the site information sections to permit a clearer perception of site conditions.

Considerable other information can be extracted from the individual descriptions of each vegetation type. Information about species-species interrelationships, species-site or species-soil relationships is evident. Despite that the study area is in the Cheyenne River Basin, the vegetation types, species, and site conditions are typically found throughout the greater northeastern and central region of Wyoming, encompassing the much larger Powder River Basin. The user needs to exercise caution in making extrapolations or interpretations beyond the stated or obvious. The vegetation types described herein are those that existed under the influence of such factors as grazing, and are not descriptions of undisturbed conditions.

One of the original objectives of the study was to identify potential cryptogams (lichens, bryophytes) that could be used as biomonitors of ambient conditions. Some information is presented in the site information section, but a complete treatise is available in Medina (In Press).

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Appendix A: Vegetation Types

1. *Pinus ponderosa-Juniperus scopulorum* (PIPO-JUSC) Coniferous forest (4 stands)

Pinus ponderosa-Juniperus scopulorum coniferous forest occurs on the east face of the north-south trending Rochelle Hills Escarpment. It is most often found at lower elevation on the more mesic north-facing slopes of small canyons.

Substrates are developed from colluvial porcellinate and sandstone materials and are shallow, very stony, medium-textured, and well-drained. Diagnostic horizons are absent except for a slightly darker colored surface horizon.

Pinus ponderosa forms a dense, closed-canopy overstory stratum. Most trees are 4–6 dm basal diameter; a few exceed 9 dm. The height of the smaller diameter trees does not exceed 10–12 m. Larger trees may be 20 m or more tall. These have the flattened crown, massive branches, and reddish, platy bark of very old trees. *Juniperus scopulorum* is present both as a secondary overstory tree and as a tall shrub. In the first instance it is a much branched, radially symmetrical tree; in the second, it is a multi-stemmed shrub, 2–3 m tall. Seedlings of both species are rare.

Understory vegetation is almost absent. *Poa secunda* is the most frequently present herbaceous plant, but it is uncommon and sparsely distributed. The ground surface is covered to a depth of 1 dm or more by an almost complete layer of pine needles. Shed pinecones are also very abundant on the ground surface and accumulations of pinecones over 2 dm deep are present in small depressions and drainage channels.

1. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
75.0			25.0			25.0	75.0	75.0	25.0	

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	10.8	16.0	2.0	25.0	75.0			50.0	50.0
Horizon 2	38.5	70.0	12.0		75.0	25.0		50.0	50.0
Horizon 3	33.5	34.0	33.0		100.0				100.0

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	5.7	6.0	5.0	6.2	8.6	3.7	.5	.7	.3
Horizon 2	6.1	6.4	5.8	4.6	6.0	2.4	.3	.4	.1
Horizon 3	6.6	6.8	6.5	7.6	7.7	7.5	.3	.5	.2

Vegetation:	Density (n/acre)	Constancy (%)
Trees		
Pinus ponderosa	23.1	100.0
Juniperus scopulorum	10.6	100.0
	Coverage (%)	**Constancy (%)**
Shrubs		
Pinus ponderosa	.7	25.0
Juniperus scopulorum	.1	25.0
Ribes inebrians	.1	25.0
Grasses and graminoids		
Poa secunda	.2	100.0
Agropyron spicatum	.1	75.0
Forbs		
Cerastium arvense	.1	50.0
Achillea lanulosa	.1	50.0
Artemisia frigida	.1	25.0
Dalea purpurea	.0	25.0
Total Herbaceous Vegetation	1.5	
Ground surface:		
Cryptograms	4.7	100.0
Litter	97.1	100.0
Bare soil	.1	75.0
Gravel and rock	3.5	100.0

2. *Juniperus scopulorum* (JUSC) Evergreen tall-shrub (4 stands)

Juniperus scopulorum evergreen tall-shrub is present on steep, side slopes of draws at the base of the Rochelle Hills Escarpment. It is not present on ridges between draws or in intermittent stream channels. Parent material is mixed colluvium. The substrate is relatively deep. A thin, non stony, but coarse-textured surface horizon overlies medium- to fine-textured subsurface horizons.

Juniperus scopulorum grows in high density stands of multi-limbed trees, usually not more than 6 m tall. Seedlings and shrub- to sapling-size individuals are all abundant. Smaller trees have radially symmetrical branching to ground level; larger trees have bushy crown form. An occasional *Pinus ponderosa* tree rises above the canopy and a few small trees of this species occur in the understory. *Artemisia tridentata* is present, but not abundant, and a true shrub stratum is absent.

The herb stratum is poorly developed, especially directly beneath the crowns of *Juniperus scopulorum*. *Agropyron spicatum* is the most common grass species; *Achillea lanulosa* and *Cerastium arvense* are the most common forb species. Litter coverage is high. Most of the litter is from *Juniperus scopulorum*.

2. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
100.0						25.0	75.0	50.0	50.0	

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	4.5	8.0	2.0		25.0	75.0	100.0		
Horizon 2	22.8	43.0	4.0		75.0	25.0	75.0	25.0	
Horizon 3	55.8	75.0	42.0	25.0	75.0		75.0	25.0	

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	5.9	6.2	5.5	8.7	9.4	7.7	1.0	1.1	1.0
Horizon 2	5.6	5.8	5.5	4.2	6.9	2.5	1.1	1.7	.9
Horizon 3	5.7	6.0	5.4	3.6	4.9	2.8	1.1	1.3	1.0

Vegetation:

	Density (n/acre)	Constancy (%)
Trees		
Juniperus scopulorum	42.5	100.0
Pinus ponderosa	1.9	50.0
	Coverage (%)	**Constancy (%)**
Shrubs		
Artemisia tridentata	.9	75.0
Grasses and graminoids		
Agropyron spicatum	1.2	100.0
Koeleria cristata	1.0	50.0
Aristida longiseta	.7	25.0
Others (2 species)	.1	
Forbs		
Achillea lanulosa	.8	100.0
Cerastium arvense	.7	100.0
Artemisia frigida	.1	75.0
Liatris punctata	.1	75.0
Taraxacum officinale	.1	50.0
Gutierrezia sarothrae	.1	25.0
Leptodactylon pungens	.1	25.0
Others (3 species)	.1	
Total Herbaceous Vegetation	6.0	
Ground surface:		
Cryptograms	12.5	
Litter	85.1	
Bare soil	7.6	
Gravel and rock	4.0	

3. *Pinus ponderosa/Agropyron spicatum* (PIPO/AGSP) Coniferous forest (13 stands)

Pinus ponderosa / Agropyron spicatum coniferous forest occupies steep upper slopes and adjacent flat ridges in the Rochelle Hills Escarpment physiographic subregion. Substrates are developed from porcellinate, limestone, and sandstone and are relatively shallow, rocky, and well-drained.

Pinus ponderosa is the only overstory tree. Trees are widely spaced, short-boled, and much branched. Most are less than 15 m tall and 6 dm basal diameter. A few have basal diameter that exceed 1 m. These have large, smooth, red-colored bark plates; massive, gnarled branches; and appear to be very old. Fire scars are uncommon on these trees. Shed pinecones are very abundant, but few seedlings or saplings of *Pinus ponderosa* are present. *Juniperus scopulorum* occasionally is present as a small tree. More often, it is a shrub less than 1 m in height. A few, widely scattered, *Artemisia tridentata* and *Eriogonum pauciflorum* are present. Both rarely exceed 0.3 m height.

The herb stratum is poorly developed, but relatively species-rich. The most abundant herbs are bunchgrasses. *Agropyron spicatum* is the characteristic species. *Koeleria cristata* and *Poa secunda* have high constancy, but low canopy coverage. *Artemisia frigida* and *Achillea lanulosa* are the most constant forbs. Both have low canopy coverage. Litter is mostly pine needles and pinecones and accumulations of pinecones 2 dm deep or more are common in drainage channels and depressions.

3. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
7.7	30.8	30.8	30.8	7.7	23.1	30.8	38.4	15.4	7.7	76.9

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	8.7	33.0	2.0		38.5	61.5	30.8	58.3	15.4
Horizon 2	25.1	42.0	10.0	7.7	46.1	46.1	30.8	46.1	23.1
Horizon 3	48.3	75.0	27.0		76.9	23.1	30.8	46.1	23.1

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.0	7.0	5.9	4.8	9.8	2.1	.6	1.0	.1
Horizon 2	6.0	7.8	3.3	5.1	2.2	1.1	.7	1.1	.2
Horizon 3	6.0	7.2	4.2	5.9	10.9	1.1	.7	1.3	.2

Vegetation:

	Density (n/acre)	Constancy (%)
Pinus ponderosa	3.8	100.0
Juniperus scopulorum	1.3	46.1
	Coverage (%)	**Constancy (%)**
Shrubs		
Artemisia tridentata	.9	46.2
Eriogonum pauciflorum	.2	58.3
Others (3 species)	.2	
Grasses and graminoids		
Agropyron spicatum	5.9	100.0
Koeleria cristata	.9	84.6
Poa secunda	.6	100.0
Bouteloua gracilis	.5	53.8
Carex filifolia	.6	46.2
Schizachyrium scoparium	1.6	15.4
Others (6 species)	1.2	
Forbs		
Artemisia frigida	.5	69.2
Achillea lanulosa	.4	61.5
Cerastium arvense	.5	46.2
Heterotheca villosa	.2	53.8
Arenaria hookeri	.1	61.5
Vicia americana	.1	61.5
Others (17 species)	1.0	
Total Herbaceous Vegetation	15.4	
Ground surface:		
Cryptograms	1.8	84.6
Litter	79.2	100.0
Bare soil	3.2	92.3
Gravel and rock	16.6	92.3

4. *Schizachyrium scoparium* (SCSC) Bunchgrass steppe (9 stands)

Schizachyrium scoparium bunchgrass steppe occurs on well-drained, exposed uplands in the Rochelle Hills Escarpment physiographic subregion and on ridges in the Eastward-sloping Plain physiographic subregion. Rocks and stones cover much of the ground surface and gravel and larger-sized coarse fragments are present throughout the relatively shallow solum. Soil texture at the surface is medium; coarse soil texture predominates in subsurface horizons.

Pinus ponderosa occurs at low density in some stands located on the Rochelle Hills Escarpment, but a well-defined tree stratum is not present. Few shrubs are present. *Yucca glauca* is the most common shrub.

Schizachyrium scoparium is the most abundant plant in the species-rich herb stratum. Tussocks may be more than 5 dm tall. The height and close spacing of the tussocks, and the golden-red color of the attached dead leaves, make it very conspicuous. The sodgrass, *Bouteloua gracilis*, is second in coverage, but its growth habit makes it inconspicuous. *Carex filifolia*, *Carex heliophila*, *Aristida longiseta*, and *Stipa comata* all are relatively abundant and indicators of the coarse-textured substrates that support this plant community. *Agropyron spicatum* is present at low coverage and constancy. Total forb coverage is low although 26 species of forbs are present. *Artemisia frigida* and *Arenaria hookeri* are the most widely distributed. The litter cover is mostly shed and attached grass leaves. Bare soil, gravel, and stones cover over half the ground surface.

4. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
44.4		33.3	22.2		44.4	44.4	12.2		11.1	88.9

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	6.0	12.0	1.0		100.0			55.6	44.4
Horizon 2	24.2	40.0	10.0	44.4	33.3	22.2	44.4	33.3	22.2
Horizon 3	50.0	85.0	30.0	11.1	11.1	77.8	44.4	22.2	33.3

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.6	7.0	6.0	3.7	5.4	1.4	.5	1.0	.1
Horizon 2	6.6	7.0	6.2	3.7	6.1	2.3	.5	1.0	.1
Horizon 3	7.1	7.7	6.2	5.3	11.1	.1	.7	1.4	.1

Vegetation:

	Density (n/acre)	Constancy (%)
Trees		
Pinus ponderosa	1.3	22.2
	Coverage (%)	**Constancy (%)**
Shrubs		
Yucca glauca	1.6	66.7
Artemisia tridentata	.6	33.3
Eriogonum pauciflorum	.1	33.3
Pinus ponderosa	.4	11.1
Grasses and graminoids		
Schizachyrium scoparium	26.3	100.0
Bouteloua gracilis	3.9	100.0
Koeleria cristata	1.0	88.9
Carex filifolia	.9	88.9
Aristida longiseta	1.1	66.7
Stipa comata	1.0	55.6
Carex heliophila	.7	55.6
Agropyron spicatum	.5	66.7
Others (7 species)	.9	
Forbs		
Artemisia frigida	.7	100.0
Arenaria hookeri	.5	100.0
Heterotheca villosa	.7	66.7
Dalea compacta	.7	55.6
Gutierrezia sarothrae	.4	55.6
Others (21 species)	2.1	
Total Herbaceous Vegetation	44.0	
Ground surface:		
Cryptograms	5.5	100.0
Litter	42.4	100.0
Bare soil	18.7	100.0
Gravel and rock	33.3	100.0

5. *Rhus trilobata/Agropyron spicatum* (RHTR/AGSP) Shrub-steppe (4 stands)

Rhus trilobata/Agropyron spicatum shrub-steppe occurs on ridges and steep, lee and windward slopes directly below ridge, in rocky, uplands on the western side of the Rochelle Hills Escarpment physiographic subregion, and on isolated buttes elsewhere in the Cheyenne River Basin. Coarse fragments of all sizes cover the ground surface and are abundant throughout the solum. Soil textures are medium to coarse in the upper solum and medium at depth. These sites are windswept throughout the year.

Rhus trilobata is distributed as scattered individual shrubs. Those growing in exposed locations are 5–7 dm tall; where sheltered by rock outcrops, height may exceed 1 m. Reproduction occurs, but is rare. In summer, the dark green foliage of *Rhus trilobata* makes stands of this plant community visible from long distance. *Artemisia tridenata* is present in most stands. *Ribes inebrians* and *Prunus virginiana* may be sympatric with *Rhus trilobata* in rock outcrop sites. Both are rare elsewhere in the Cheyenne River Basin.

Agropyron spicatum is moderately abundant in the herb stratum. Tussocks are somewhat large and have a considerable amount of attached dead leaves and seeds stem. *Schizachyrium scoparium* is present in some stands; *Bromus tectorum* is present in all stands. Other grasses and sedges are those found throughout Cheyenne River Basin in rocky exposed locations. The forb component of the herb stratum is species-rich. *Leptodactylon pungens* and *Astragalus spatulatus* are the most common and abundant species. Litter is relatively sparse.

5. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
50.0			50.0			25.0	75.0		25.0	75.0

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	7.8	9.0	6.0		50.0	50.0			100.0
Horizon 2	42.0	55.0	26.0		75.0	25.0			100.0
Horizon 3	69.0	72.0	65.0		100.0				100.0

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.4	6.9	5.5	4.4	6.3	3.1	.3	.4	.1
Horizon 2	6.9	7.7	5.5	11.0	23.0	3.0	.3	.4	.1
Horizon 3	7.6	7.9	7.3	8.7	16.8	2.7	.4	.5	.3

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Rhus trilobata	10.1	100.0
Artemisia tridentata	2.5	75.0
Ribes inebrians	2.4	50.0
Eriogonum brevicaule	.6	75.0
Chrysothamnus viscidiflorus	.5	25.0
Prunus virginiana	.1	25.0
Others (2 species)	.1	
Grasses and graminoids		
Agropyron spicatum	11.6	100.0
Bouteloua gracilis	2.5	75.0
Bromus tectorum	1.3	100.0
Stipa comata	2.1	25.0
Koeleria cristata	.6	100.0
Poa secunda	.5	75.0
Carex filifolia	.3	50.0
Schizachyrium scoparium	.3	25.0
Forbs		
Leptodactylon pungens	1.5	100.0
Astragalus spatulatus	1.5	75.0
Arenaria hookeri	.5	100.0
Dalea purpurea	.4	75.0
Artemisia frigida	.3	100.0
Opuntia polyacantha	.4	50.0
Others (14 species)	1.4	
Total Herbaceous Vegetation	41.5	
Ground surface:		
Cryptograms	2.2	75.0
Litter	21.2	100.0
Bare soil	5.7	100.0
Gravel and rock	87.1	100.0

6. *Artemisia tridentata/Agropyron spicatum* (ARTR/AGSP) Shrub-steppe (7 stands)

Artemisia tridentata/Agropyron spicatum shrub-steppe is present on ridges in the Rolling Divide physiographic subregion and on middle and upper slopes of the many porcellinate and sandstone buttes scattered over the Cheyenne River Basin. The substrate is relatively shallow and stony throughout the solum. Surface soils tend to be coarse-textured and well-drained. Infiltration is rapid and root penetration deep.

A relatively species-rich shrub stratum is present. *Artemisia tridentata* is the characteristic species. Mature plants are usually more than 5 dm tall with moderately compact, rounded crowns. *Atriplex gardnerii* and *Eriogonum ovalifolium* are relatively abundant; *Chrysothamnus viscidiflorus* is less common. *Juniperus scopulorum* may be present at low density when there is a nearby source of seed .

Agropyron spicatum is the characteristic species of the herb stratum. Its tussocks are usually well-developed. Reproductive culms may be more than 5 dm tall. *Carex filifolia* can be locally abundant, but is not widely distributed. Other relatively common grasses are *Poa secunda*, *Koeleria cristata*, and *Oryzopsis hymenoides*. *Bouteloua gracilis* is uncommon. The most common and widely distributed forbs are *Arenaria hookeri* and *Artemisia frigida*. Litter is mainly from grasses and coverage is low. Coarse fragments and bare soil cover over 80% of the ground surface.

6. Site Information

Surface:	Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
	North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
	28.6	14.3		57.1			14.3	85.7	15.3	57.1	27.6

Substrate:	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	6.9	20.0	2.0		42.9	57.1		85.7	14.3
Horizon 2	18.1	24.0	7.0	28.6	42.9	28.6	57.1	28.6	14.3
Horizon 3	37.1	60.0	15.0		85.7	14.3	57.1	14.3	28.6

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	7.0	7.5	5.2	7.6	12.4	2.6	.8	1.8	.2
Horizon 2	6.9	7.7	4.6	8.7	16.0	2.9	1.5	6.7	.2
Horizon 3	7.0	7.7	4.6	6.4	13.0	0.0	1.8	7.5	0.0

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	6.9	85.7
Atriplex gardneri	.7	57.1
Eriogonum ovalifolium	.7	42.9
Chrysothamnus viscidiflorus	.5	28.6
Juniperus scopulorum	.4	14.3
Others (3 species)	.2	
Grasses and graminoids		
Agropyron spicatum	17.4	100.0
Carex filifolia	2.1	28.6
Poa secunda	.5	42.9
Koeleria cristata	.4	42.9
Oryzopsis hymenoides	.2	42.9
Bouteloua gracilis	.8	14.3
Others (2 species)	.4	
Forbs		
Arenaria hookeri	1.2	71.4
Artemisia frigida	1.1	71.4
Astragalus aboriginum	.5	28.6
Phlox hoodii	.3	57.1
Sphaeralcea coccinea	.3	57.1
Phlox hoodii	.3	57.1
Vicia americana	.3	57.1
Leptodactylon pungens	.3	42.9
Others (19 species)	2.0	
Total Herbaceous Vegetation	37.5	
Ground surface:		
Cryptograms	3.6	100.0
Litter	21.7	100.0
Bare soil	20.4	85.7
Gravel and rock	62.0	100.0

7. *Artemisia tridentata/Bouteloua gracilis Agropyron spicatum* (ARTR/BOGR-AGSP) Shrub-steppe (12 stands).

Artemisia tridentata/Bouteloua gracilis-Agropyron spicatum shrub-steppe is present on the tops of level to gently rounded ridges and uplands in the Cheyenne River Basin. These exposed locations tend to be windy throughout the year. It occurs both east and west of the Rochelle Hills Escarpment, but not on the escarpment itself. Coarse fragments and gravel are abundant on the substrate surface and at deeper levels in the solum. A weakly developed, fine-textured horizon is present directly beneath the epipedon.

Artemisia tridentata forms an open shrub stratum from 2–5 dm high. Most plants are low-growing and have compact, rounded crowns. The only other shrubs are *Eriogonum pauciflorum* and *Eriogonum ovalifolium*. Both have a prostrate growth habit and are inconspicuous, except when in flower.

Bouteloua gracilis is the characteristic species in the species-rich herb stratum. It has relatively high canopy coverage. *Agropyron spicatum* has much less coverage, but because of its tussock growth habit is more easily seen than *Bouteloua gracilis* and gives the herb stratum its visual aspect. Other common grasses are *Koeleria cristata*, *Poa secunda*, *Stipa comata*, and *Agropyron smithii*. The sympatric nature of *Bouteloua gracilis*, *Agropyron smithii*, and *Agropyron spicatum* is another example of the broad transitional nature of the vegetation in the Cheyenne River Basin. *Arenaria hookeri* is the most common and abundant of the 26 species of forbs. *Gutierrezia sarothrae*, *Artemisia frigida*, and *Phlox hoodii* are less common and abundant. A sparse litter cover is present.

7. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
	16.7	16.7	66.6	75.0	16.7	8.3		8.3	8.3	83.4

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	5.3	10.0	2.0	8.3	75.0	16.7	8.3	16.7	75.0
Horizon 2	20.6	35.0	9.0	83.3		16.7	33.3	8.3	58.4
Horizon 3	43.5	70.0	28.0	8.3	75.0	16.7	25.0	58.3	16.7

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.8	7.9	6.0	6.0	13.2	2.4	1.3	5.0	.4
Horizon 2	6.9	7.9	6.2	10.5	22.5	3.2	2.1	7.1	.6
Horizon 3	6.8	7.8	6.0	13.6	27.2	4.8	2.8	8.1	.6

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	4.9	100.0
Eriogonum pauciflorum	.3	50.0
Eriogonum ovalifolium	.1	33.3
Others (3 species)	.5	
Grasses and graminoids		
Bouteloua gracilis	15.1	100.0
Agropyron spicatum	6.6	75.0
Koeleria cristata	2.1	66.7
Poa secunda	1.6	75.0
Stipa comata	1.7	66.7
Agropyron smithii	1.0	41.7
Others (8 species)	1.6	
Forbs		
Arenaria hookeri	3.5	100.0
Gutierrezia sarothrae	1.5	91.7
Artemisia frigida	1.4	75.0
Phlox hoodii	1.2	75.0
Astragalus spatulatus	1.1	58.3
Others (21 species)	2.0	
Total Herbaceous Vegetation	46.2	
Ground surface:		
Cryptograms	4.9	83.3
Litter	28.5	100.0
Bare soil	17.1	91.7
Gravel and rock	46.5	100.0

8. *Artemisia tridentata/Stipa viridula* (ARTR/STVI) Shrub-steppe (2 stands)

Artemisia tridentata / Stipa viridula shrub-steppe has limited distribution in the Cheyenne River Basin. It is present on level ridges and upper slopes in the Dissected Upland topographic subregion west of the Rochelle Hills Escarpment. The ground surface has small scale gilgai microrelief. Changes in elevation of 1–2 dm are present. Much of the ground surface is bare substrate. Small stones are scattered over the substrate surface, but there are no stones in the solum. Intense summer rainfall tends to saturate the surface substrate. Infiltration is slow and water ponds in the microbasins for several hours after the rain stops.

Artemisia tridentata forms an evenly distributed shrub stratum. Most shrubs are less than 3 dm tall and have compact, rounded crowns. In spite of its small stature, *Artemisia tridentata* has relatively high canopy coverage because of close spacing. *Yucca glauca* and *Atriplex canescens* are the only other shrubs.

The herb stratum is species-rich in graminoids, but species-poor in forbs. *Stipa viridula* is the characteristic species. Its tussocks are closely spaced and reproductive culms exceed 8 dm height. The tall culms partially conceal the low growing *Artemisia tridentata* and from a distance the vegetation appears to be grassland, not shrub-steppe. Other grasses are those common to the Cheyenne River Basin. Crustose lichens are relatively common on the ground surface. Grass litter covers nearly half of the ground surface.

8. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
50.0			50.0	50.0	50.0					100.0

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	2.5	4.0	1.0		50.0	50.0	100.0		
Horizon 2	9.0	13.0	5.0	50.0		50.0	100.0		
Horizon 3	26.5	40.0	13.0	50.0	50.0		100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.6	7.2	6.0	5.7	11.1	.1	.2	.3	.1
Horizon 2	7.0	7.2	6.8	7.9	14.5	1.7	.4	.5	.3
Horizon 3	7.3	7.3	7.2	7.6	9.5	1.4	.8	1.5	.2

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	13.9	100.0
Yucca glauca	.9	50.0
Atriplex canescens	.5	50.0
Grasses and graminoids		
Stipa viridula	24.1	100.0
Bouteloua gracilis	9.0	50.0
Agropyron spicatum	3.2	100.0
Stipa comata	5.2	50.0
Carex heliophila	2.0	50.0
Koeleria cristata	1.4	50.0
Carex filifolia	1.1	50.0
Others (2 species)	.7	
Forbs		
Artemisia frigida	3.0	50.0
Gutierrezia sarothrae	1.9	50.0
Leucocrinum montanum	.9	50.0
Sphaeralcea coccinea	.6	50.0
Psoralea argophylla	.3	50.0
Vicia americana	.2	50.0
Others (5 species)	.2	
Total Herbaceous Vegetation	69.1	
Ground surface:		
Cryptograms	12.2	50.0
Litter	44.0	100.0
Bare soil	41.2	100.0
Gravel and rock	.6	50.0

9. *Artemisia pedatifida* (ARPE)
Dwarf-shrub (5 stands)

Artemisia pedatifida dwarf-shrub occurs in the Dissected Upland physiographic subregion. It is confined to slightly concave terrain (pans) on flat to rolling upland ridges. The substrate in the pans has a thin, friable, medium-coarse textured surface horizon overlying a fine-textured, tightly packed subsurface horizon with impeded drainage. The surface horizon is quickly saturated by rain, but water does not infiltrate to deeper depths. Normal hot dry summer weather rapidly dries the surface horizon. The alternately saturated and desiccated substrate conditions are responsible for the distinctive species composition.

The plant community is essentially single layered with a relatively species-rich shrub component. *Artemisia pedatifida* is suffruticose and rarely more than 1 dm in height. It has rather uniform, unclumped, distribution. Canopy coverage is surprisingly high. All other shrub species are also much reduced in height and scraggled. The presence of *Eriogonum pauciflorum*, *Atriplex gardnerii*, and *Ceratoides lanata* indicates saline-alkali substrate conditions. The herb component of the vegetation is species-poor. Only *Agropyron smithii* and *Musineon divaricatum* are important. The culms of *Agropyron smithii* are short with few leaves and the plants are widely spaced. A well-defined sod is absent. *Musineon divaricatum* forms prostrate, individual clumps, less than 1 dm across and 2 cm high. It tends to flower repeatedly when the substrate is wet and the bright yellow flowers make it very conspicuous. Most of the ground surface is bare; litter is almost absent.

9. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
		40.0	60.0	100.0				20.0		80.0

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	4.0	10.0	1.0		80.0	20.0	60.0	40.0	
Horizon 2	17.0	32.0	4.0	40.0	40.0	20.0	80.0	20.0	
Horizon 3	21.0	32.0	8.0	40.0	60.0		100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	7.0	7.5	6.5	5.3	10.1	3.0	.4	.5	.2
Horizon 2	7.2	7.6	6.7	8.3	10.1	6.6	1.0	1.4	.3
Horizon 3	7.3	7.8	6.6	8.9	13.7	0.0	1.3	2.9	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia pedatifida	18.1	100.0
Eriogonum pauciflorum	.9	40.0
Atriplex gardneri	.9	40.0
Ceratoides lanata	.4	40.0
Artemisia tridentata	.3	20.0
Others (2 species)	.1	
Grasses and graminoids		
Agropyron smithii	3.4	100.0
Carex filifolia	1.0	40.0
Poa secunda	.7	60.0
Bouteloua gracilis	.3	60.0
Oryzopsis hymenoides	.3	20.0
Sitanion hystrix	.1	40.0
Forbs		
Musineon divaricatum	1.3	100.0
Vicia americana	.6	60.0
Phlox hoodii	.2	60.0
Cymopteris acaulis	.2	40.0
Lomatium foeniculaceum	.1	40.0
Others (2 species)	.3	
Total Herbaceous Vegetation	29.2	
Ground surface:		
Cryptograms	.3	80.0
Litter	2.6	100.0
Bare soil	75.8	100.0
Gravel and rock	2.7	100.0

10. *Atriplex canescens* (ATCA)
Shrub (3 stands)

Atriplex canescens shrub is present on steep, side slopes in badlands terrain. The badlands of the Cheyenne River Basin are formed by erosion of shale and sandstone and are most prevalent in the Eastward-sloping Plain physiographic subregion. Badlands form an intricate maze of narrow ravines, sharply crested ridges, and flat-topped pinnacles. Pinnacles are often capped with harder rock and support other types of rangeland vegetation. Purple, orange, tan, and white-colored layers of geological materials and seams of carbonaceous shale and coal are common on side slopes where *Atriplex canescens* shrub is present. The solum is relatively shallow and stone-free, but stones are occasionally present on the ground surface. The substrate may be horizontally subdivided by both genetic horizons or depositional layers. Soil reaction is acidic through the solum.

The shrub stratum is poorly developed. *Atriplex canescens* is the characteristic species. It has a bushy growth habit and may be 5–7 dm in height. *Atriplex canescens* reproduction is present. Other shrubs are erratically distributed. Where present, they are generally poorly developed and widely spaced, and seedlings are rare.

Few herbs are present and a well-defined herb stratum is lacking. *Agropyron smithii* and *Artemisia ludoviciana* are the most abundant and common species. Neither are sufficiently important to be characteristic. Litter is uncommon and consists of woody debris for the most part.

10. Site Information

Surface:	Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
	North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
			33.3	66.7		33.3		66.7			100.0

Substrate:	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	1.7	2.0	1.0		100.0		33.3	66.7	
Horizon 2	8.3	10.0	6.0		66.7	33.3	100.0		
Horizon 3	22.3	27.0	18.0		66.7	33.3	100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	5.4	6.7	4.0	13.2	20.6	7.1	1.2	1.9	.6
Horizon 2	5.6	6.9	6.0	13.2	24.2	5.8	1.6	2.9	.2
Horizon 3	5.6	7.0	4.5	10.0	19.4	4.5	2.6	5.6	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Atriplex canescens	7.6	100.0
Eriogonum pauciflorum	1.8	66.7
Artemisia tridentata	1.2	33.3
Chrysothamnus nauseosus	.1	33.3
Grasses and graminoids		
Agropyron smithii	5.7	66.7
Poa annua	.2	66.7
Others (2 species)	.1	
Forbs		
Artemisia ludoviciana	6.3	66.7
Sphaeralcea coccinea	.5	33.3
Atriplex dioeca	.3	33.3
Cymopteris acaulis	.2	33.3
Commandra pallida	.1	16.7
Others (2 species)	.1	
Total Herbaceous Vegetation	24.2	
Ground surface:		
Cryptograms		
Litter	10.0	100.0
Bare soil	89.3	100.0
Gravel and rock	2.8	100.0

11. *Artemisia cana/Bouteloua gracilis-Calamovilfa longifolia* (ARCA/BOGR-CALO) Shrub-steppe (6 stands)

Artemisia cana/Bouteloua gracilis-Calamovilfa longifolia shrub-steppe occurs on sand dunes in the Dissected Upland and Rolling Divide physiographic subregions of the Cheyenne River Basin. Most sand dunes are oriented with the prevailing wind (seif dunes) and associated with river drainages. Dunes may be as high as 20 m. Many sand dunes are adequately stabilized by vegetation: some are actively aggrading or degrading and sand blowouts are present on some stabilized dunes. The substrate is relatively deep and has medium and coarse textures throughout the solum. It is very well-drained, but not xeric because short term, high intensity summer rain showers are not uncommon, infiltration is high, and roots are able to penetrate deeply to reach moisture.

Artemisia cana forms a well-defined shrub stratum 5 dm or more high. The shrubs are vigorous, with many limbs and large, succulent leaves. Many small *Artemisia cana* are present. *Artemisia tridentata* and *Chrysothamnus viscidiflorus* are occasional components of the shrub stratum.

Many species of grasses occur. *Bouteloua gracilis* and *Calamovilfa longifolia* are codominants in the herb stratum. The latter species is more visible because of its upright growth habit and tall reproductive culms. *Stipa comata* is less abundant, but always present. *Bromus tectorum* occurs where livestock grazing is heavy. Many forb species are present, but none are abundant. Litter covers almost one-third of the ground surface.

11. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
	50.0	16.7	33.3	66.6	16.7	16.7		66.6	16.7	16.7

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	5.7	10.0	3.0	16.7	33.3	50.0	100.0		
Horizon 2	17.2	30.0	9.0		50.0	50.0	100.0		
Horizon 3	43.0	60.0	27.0		66.7	33.3	100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.2	7.2	4.0	4.1	7.5	2.4	2.0	10.4	.1
Horizon 2	6.9	7.6	6.5	3.2	5.2	2.2	.4	1.0	.1
Horizon 3	7.1	7.6	6.7	5.7	12.0	2.7	.5	1.2	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia cana	20.0	100.0
Artemisia tridentata	1.7	33.3
Chrysothamnus viscidiflorus	.3	50.0
Grasses and graminoids		
Bouteloua gracilis	11.8	100.0
Calamovilfa longifolia	11.4	100.0
Bromus tectorum	8.7	83.3
Stipa comata	7.1	100.0
Agropyron smithii	8.3	66.7
Poa secunda	2.8	50.0
Others (8 species)	2.2	
Forbs		
Artemisia frigida	1.9	66.7
Commandra pallida	.5	50.0
Sphaeralcea coccinea	.4	50.0
Cryptantha bradburyiana	.7	33.3
Draba reptans	.7	33.3
Others (13 species)	1.2	
Total Herbaceous Vegetation	79.7	
Ground surface:		
Cryptograms	.3	50.0
Litter	33.6	100.0
Bare soil	73.0	100.0
Gravel and rock	2.0	33.3

12. *Yucca glauca/Stipa comata* (YUGL/STCO) Shrub-steppe (6 stands)

Yucca glauca/Stipa comata shrub-steppe occurs on outcrops of sandstone, but not on sand dunes, in the Eastward-sloping Plain physiographic subregion on the Cheyenne River Basin. It is present only on the immediate ridge and does not extend downward onto upper slopes. Substrates are residual origin, relatively deep, and have genetic horizon. Soil texture ranges from almost pure sand on the surface to medium and medium-coarse at depth. The substrate is well-drained, but not xeric. Moist soil is present in summer at depths below 5 dm. Roots penetrate to 1 m or more.

Yucca glauca is a minor component in other vegetation types on coarse-textured substrates. In this one it is definitely the characteristic species in the shrub stratum. It grows both as a single plant and in dense clumps. Small (young?) plants are common. The sharp-pointed leaves of the subacaulescent clusters may exceed 5 dm height and the inflorescence may be 2 m or more tall.

The location of the vegetation type can be identified from considerable distance when *Yucca glauca* is in flower. *Artemisia* spp. are a minor component.

Stipa comata is the most abundant and characteristic species in the species-rich herb stratum. In the Cheyenne River Basin this grass has an affinity for coarser textured substrates, as do *Calamovilfa longifolia*, *Carex filifolia*, and *Aristida longiseta*, all of which are abundant and common. Other grasses, and forbs are those widely distributed in the area. Litter is common, but over one-third of the ground surface is bare of cover.

12. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
16.7	16.6	50.0	16.7	33.3	50.0	16.7				100.0

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	6.0	11.0	2.0		33.3	66.7	83.3	16.7	
Horizon 2	19.7	35.0	8.0		83.3	16.7	83.3	16.7	
Horizon 3	41.5	70.0	18.0		50.0	50.0	83.3	16.7	

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.6	7.3	5.8	2.4	7.2	.7	.4	.8	.1
Horizon 2	6.8	7.5	5.9	3.2	9.9	1.1	.4	1.0	.1
Horizon 3	7.0	8.1	6.2	3.2	5.2	1.1	.5	1.4	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Yucca glauca	9.8	100.0
Artemisia tridentata	1.4	33.3
Artemisia cana	1.2	33.3
Grasses and graminoids		
Stipa comata	16.3	100.0
Calamovilfa longifolia	8.7	100.0
Bouteloua gracilis	8.2	83.3
Carex filifolia	7.1	83.3
Poa secunda	1.8	50.0
Aristida longiseta	.8	66.7
Bromus tectorum	.7	66.7
Koeleria cristata	.5	66.7
Others (7 species)	2.2	
Forbs		
Opuntia polyacantha	1.3	50.0
Artemisia frigida	.7	83.3
Psoralea argophylla	1.1	33.3
Lupinus pusillus	.4	33.3
Gaura coccinea	.2	33.3
Others (15 species)	1.7	
Total Herbaceous Vegetation	64.1	
Ground surface:		
Cryptograms	2.7	100.0
Litter	57.8	100.0
Bare soil	38.5	100.0
Gravel and rock	.3	50.0

13. *Stipa comata-Bouteloua gracilis* (STCO-BOGR) Sodgrass steppe (14 stands)

Stipa comata-Bouteloua gracilis sodgrass steppe occurs throughout the Cheyenne River Basin on ridges and slopes where the substrate has coarse to medium soil texture throughout the solum. Most often it occurs in level to rolling terrain and is not present on sand dunes or sandstone outcrops. The substrate is deep and has well-developed horizons. Free calcium carbonates occasionally are present in deeper soil horizons.

The vegetation is true grassland. The only shrubs are scattered, poorly developed, *Artemisia tridentata* and an occasional *Yucca glauca*. Grasses characterize the herb stratum. *Bouteloua gracilis* and *Stipa comata* are the characteristic species. The former is the more abundant; the latter gives the vegetation its visual aspect because of its upright growth habit. *Agropyron smithii* and *Poa secunda* are less abundant, but widely distributed. Two introduced grasses are locally abundant. Both have restricted distribution. The annual, *Bromus tectorum*, forms dense stands where the range is overgrazed or where fairly recent wildfires have burned. These two factors often act in accord to sustain its presence: overgrazing allows invasion; the dense stands that result are prone to repeated burning. *Agropyron desertorum* is seeded for restoration of deteriorated rangelands and has been naturally established in some native rangelands next to the seeded ranges. *Opuntia polyacantha* is the most abundant and common forb. It forms almost closed-canopy clusters several meters across in some locations. Grass leaf litter covers more than 60% of the ground surface; bare ground and stones more than 35%.

13. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
14.3	35.7	35.7	14.3	64.3	14.3	21.4		14.3	21.4	64.3

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	2.0	10.0	2.0		21.4	78.6	71.4	21.4	7.2
Horizon 2	19.2	42.0	8.0		50.0	50.0	64.3	28.6	7.1
Horizon 3	51.5	90.0	31.0		64.3	35.7	64.3	14.3	21.4

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.1	7.0	5.2	2.8	5.8	.8	.7	1.3	.1
Horizon 2	6.2	7.5	5.4	4.3	20.0	1.2	.8	1.4	.1
Horizon 3	6.8	7.7	5.9	6.0	15.8	1.2	1.2	3.7	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	2.0	64.3
Yucca glauca	1.5	21.4
Others (3 species)	.1	
Grasses and graminoids		
Stipa comata	11.3	85.7
Bouteloua gracilis	9.8	92.9
Poa secunda	1.5	78.6
Koeleria cristata	1.1	85.7
Agropyron smithii	.9	78.6
Agropyron desertorum	4.5	14.3
Carex filifolia	.7	50.0
Calamovilfa longifolia	.7	14.3
Others (8 species)	2.9	
Forbs		
Opuntia polyacantha	2.4	71.4
Artemisia frigida	.6	78.6
Sphaeralcea coccinea	.2	78.6
Gutierrezia sarothrae	.4	35.7
Leptodactylon pungens	.1	35.7
Arenaria hookeri	.2	28.6
Others (22 species)	.8	
Total Herbaceous Vegetation	41.7	
Ground surface:		
Cryptograms	2.1	100.0
Litter	61.2	100.0
Bare soil	27.1	92.9
Gravel and rock	8.9	50.0

14. *Artemisia cana/Bouteloua gracilis* (ARCA/BOGR) Shrub-steppe (6 stands)

Artemisia cana/Bouteloua gracilis shrub-steppe occurs on the alluvial terraces that border the larger creeks and rivers of the Cheyenne River Basin. Most terraces are raised at least 1 m above the floodplain surface. The alluvium is deep, medium- to fine-textured, and almost free of stones. It is loosely compacted and well-drained. Root penetration is deep. Both genetic horizons and depositional layers are present in the substrate.

Artemisia cana is the characteristic species of a well-developed shrub stratum. It grows in an open stand of bushy shrubs that rarely exceed 5 dm height. The silver-grey color of *Artemisia cana* foliage is distinctive and allows stands of this vegetation type to be located from long distance. Other shrub species are uncommon.

Sodgrasses are the predominant life-form in the herb stratum. *Bouteloua gracilis* is the most abundant and characteristic species. *Agropyron smithii* is less abundant and also ubiquitous. *Stipa comata, Calamovilfa longifolia,* and *Oryzopsis hymenoides* can be locally abundant. All are erratically distributed. None of the many forb species present are abundant. Only a moderate cover of litter is present. Much of the ground surface is bare substrate. A few water-deposited stones occur on the substrate surface.

14. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
	33.3	33.3	33.3	33.3	66.7			50.0	50.0	

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	2.5	5.0	1.0	16.7	66.7	16.7	83.3	16.7	
Horizon 2	22.5	66.0	7.0	33.3	66.7		100.0		
Horizon 3	52.3	97.0	30.0	33.3	66.7		100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.3	7.4	5.0	3.9	6.2	.9	.4	1.0	.1
Horizon 2	6.3	7.3	5.2	4.4	8.4	.9	.5	1.0	.1
Horizon 3	6.4	7.4	4.6	3.0	7.0	.9	.4	.9	.1

Vegetation:

	Coverage (%)	Constancy (%)
Shrubs		
Artemisia cana	7.9	100.0
Yucca glauca	.9	16.7
Artemisia tridentata	.4	16.7
Chrysothamnus nauseosus	.1	33.3
Others (2 species)	.2	
Grasses and graminoids		
Bouteloua gracilis	16.7	100.0
Agropyron smithii	7.9	100.0
Stipa comata	1.9	66.7
Calamovilfa longifolia	1.5	33.3
Oryzopsis hymenoides	1.3	16.7
Poa secunda	.2	50.0
Others (8 species)	1.0	
Forbs		
Commandra pallida	.1	66.7
Artemisia frigida	.1	50.0
Sphaeralcea coccinea	.2	33.3
Thermopsis rhombifolia	.2	33.3
Arenaria hookeri	.1	33.3
Cirsium undulatum	.1	33.3
Heterotheca villosa	.1	33.3
Others (8 species)	.6	
Total Herbaceous Vegetation	41.5	
Ground surface:		
Cryptograms	.3	100.0
Litter	37.5	100.0
Bare soil	58.2	100.0
Gravel and rock	4.3	50.0

15. *Artemisia tridentata/Agropyron smithii* (ARTR/AGSM) Shrub-steppe (4 stands)

Artemisia tridentata / Agropyron smithii shrub-steppe occurs on uplands both east and west of the Rochelle Hills Escarpment. It is confined to the floodplain and lower slopes of small, natural drainage ways that usually lack a well defined, incised stream channel. Soil moisture conditions are relatively mesic. Water remains on the surface during, and for a short time after, periods of high rainfall in summer. Wind-blown snow accumulates in the draws in winter and snowdrifts may remain well into the spring. Surface substrates tend to be medium-textured; deeper horizons have medium to fine textures. Stones are present in the deeper horizons in some locations.

Artemisia tridentata forms a well-defined stratum of shrubs that range from less than 1 dm to more than 1 m in height. Most mature plants are 4–7 dm tall, have succulent glaucous leaves, prolific twig growth, and appear healthy and vigorous. An occasional *Artemisia cana* is the only other shrub present.

Grasses are the predominant life form in the herbaceous stratum. *Agropyron smithii* grows vigorously and can form an unbroken sod cover. *Poa secunda* also is relatively abundant and equally common, but always a subordinate species. Other important grasses are *Koeleria cristata* and *Stipa viridula*. The low abundance of *Bouteloua gracilis* is a distinguishing characteristic of this vegetation. The forb component is species-rich. The most abundant forb is *Achillea lanulosa*. Grass leaf litter covers about three-quarters of the ground; bare soil and stones most of the remainder. Cryptograms are rare.

15. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
	75.0		25.0	75.0		25.0		75.0	25.0	

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	4.3	7.0	2.0		75.0	25.0	100.0		
Horizon 2	16.5	21.0	7.0	25.0	50.0	25.0	100.0		
Horizon 3	32.8	44.0	21.0		50.0	50.0	50.0		50.0

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.2	6.4	6.0	3.8	6.0	1.2	.4	.9	.1
Horizon 2	6.4	7.0	6.1	3.6	6.6	1.4	.7	2.0	.1
Horizon 3	6.6	7.2	6.3	2.6	6.0	.2	1.3	4.5	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	24.1	100.0
Eriogonum ovalifolium	.1	50.0
Artemisia cana	.1	50.0
Grasses and graminoids		
Agropyron smithii	22.3	100.0
Poa secunda	12.0	100.0
Koeleria cristata	6.0	75.0
Stipa comata	3.8	75.0
Bromus tectorum	3.9	50.0
Bouteloua gracilis	2.0	50.0
Others (3 species)	.2	
Forbs		
Achillea lanulosa	3.9	75.0
Vicia americana	.9	50.0
Artemisia frigida	.5	75.0
Gutierrezia sarothrae	.4	50.0
Cymopteris acaulis	.1	75.0
Lomatium foeniculatum	.4	50.0
Sphaeralcea coccinea	.3	50.0
Others (12 species)	1.6	
Total Herbaceous Vegetation	82.6	
Ground surface:		
Cryptograms	1.7	100.0
Litter	75.8	100.0
Bare soil	22.3	75.0
Gravel and rock	4.1	75.0

16. *Artemisia tridentata/Bouteloua gracilis-Agropyron smithii* (ARTR/BOGR-AGSM) Shrub-steppe (15 stands)

Artemisia tridentata/Bouteloua gracilis-Agropyron smithii shrub-steppe is the most widely distributed vegetation type in the Cheyenne River Basin. It occurs on level to gently rolling, wind-exposed, upland slopes and ridges both east and west of the Rochelle Hills Escarpment. It is more common to the west. Substrates are relatively deep and have weak to moderately well- developed profiles. Surface soils are medium to coarse soil texture; deeper horizons are more medium-textured and alluvial.

Artemisia tridentata forms a very well-developed shrub stratum 4–6 dm tall. Distribution is weakly clumped and crowns of individual shrubs in a clump may slightly overlap. Crowns are compact and rounded, and appear hedged; however, little evidence of browsing is present. Other shrub species are rare and erratically distributed.

Bouteloua gracilis forms sod mats several meters across and is the characteristic species. *Agropyron smithii* may be as abundant as *Bouteloua gracilis*; more often it is less so. *Stipa comata*, *Poa secunda*, and *Koeleria cristata* are the other common grasses of the herb stratum. *Carex filifolia* is less widely distributed, but may be locally abundant. In some locations, the succulent forb, *Opuntia polyacantha*, appears to be very abundant. Actual horizontal coverage is moderate; apparent abundance is an artifact of leaf orientation and the low oblique angle at which it is seen. Grass leaf litter covers much of the ground surface. Cryptograms are relatively common.

16. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
20.2	26.7	13.3	39.8	66.7	26.7	6.6		20.0	26.7	53.3

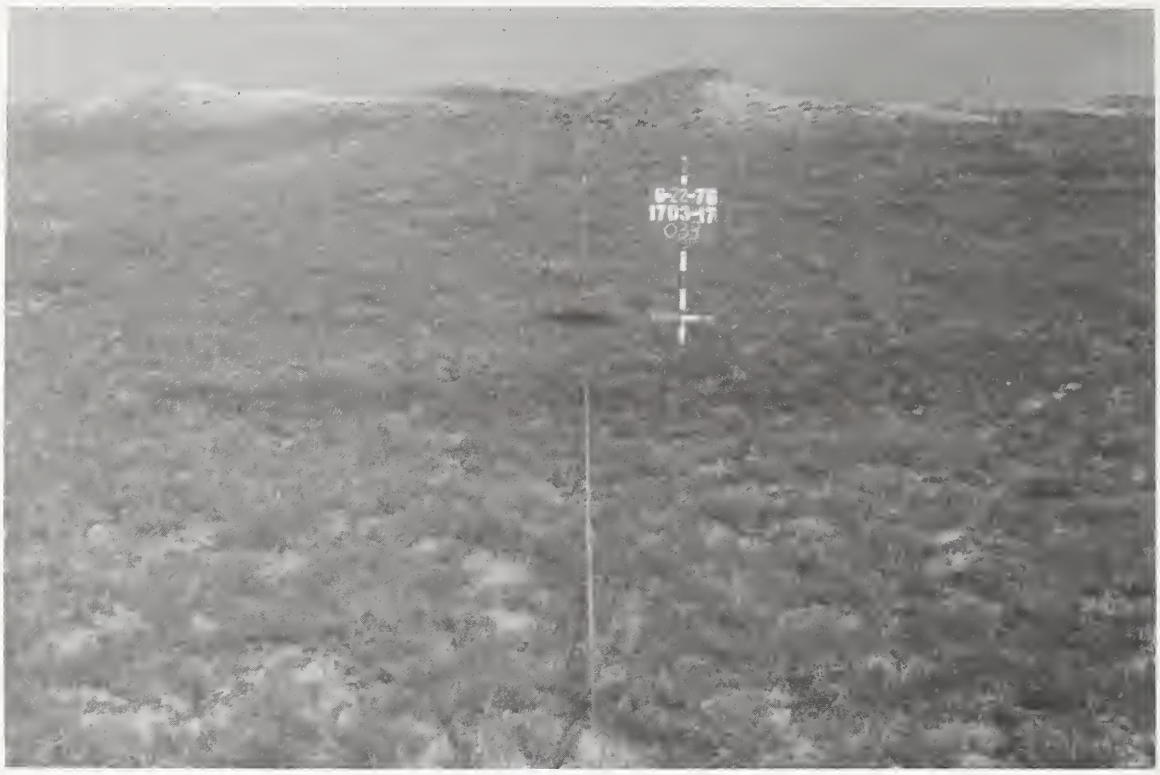
Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	5.2	12.0	2.0		53.3	46.7	86.7		13.3
Horizon 2	20.9	37.0	6.0		66.7	33.3	86.7		13.3
Horizon 3	51.0	97.0	15.0		86.7	13.3	80.0	6.7	13.3

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	5.8	7.4	4.0	3.2	6.8	1.1	.4	1.0	.1
Horizon 2	6.2	7.4	4.4	6.6	32.0	0.0	.5	1.0	0.0
Horizon 3	6.8	8.0	5.3	7.7	18.3	1.6	.6	1.3	.2

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	22.3	100.0
Others (6 species)	.4	
Grasses and graminoids		
Bouteloua gracilis	9.4	100.0
Agropyron smithii	6.2	100.0
Stipa comata	3.5	86.7
Poa secunda	2.3	86.7
Carex filifolia	2.4	40.0
Koeleria cristata	1.3	73.3
Festuca octoflora	1.4	26.7
Agropyron spicatum	1.7	20.0
Bromus tectorum	1.4	20.0
Others (3 species)	.2	
Forbs		
Opuntia polyacantha	3.6	86.7
Artemisia frigida	1.7	60.0
Psoralea argophylla	1.7	20.0
Gaura coccinea	1.9	13.3
Astragalus crassicarpus	2.9	6.7
Others (15 species)	1.8	
Total Herbaceous Vegetation	66.1	
Ground surface:		
Cryptograms	8.3	100.0
Litter	69.3	100.0
Bare soil	21.0	100.0
Gravel and rock	7.9	46.7

17. *Bouteloua gracilis-Carex filifolia* (BOGR-CAFI)
Sodgrass steppe (11 stands)



Bouteloua gracilis-Carex filifolia sodgrass steppe is prevalent in the Eastward-sloping Plain physiographic subregion of the Cheyenne River Basin. It is found on level to rolling ridges and upper slopes where soil texture is medium and coarse throughout the solum and almost free of stones. Substrates are relatively deep and genetic horizons are present. Soil reaction is neutral to basic in all horizons. Free calcium carbonates occur in subsurface horizons.

Several species of shrubs are present. All are poorly developed and widely scattered and a well-defined shrub stratum is absent. The two characteristic species of the herb stratum are *Bouteloua gracilis* and *Carex filifolia*. The former is almost ubiquitous in the vegetation of the Cheyenne River Basin. It provides almost half the total plant coverage in this plant community. The sedge, *Carex filifolia*, is also widely distributed, but usually as a subordinate species. It is most common where the substrate has medium to coarse textures. Its abundance here reflects that affinity. The other grasses and forbs are those found throughout the area. Of these, only *Stipa comata* is relatively abundant and common. Cryptograms are common and relatively abundant on the ground surface. Grassleaf litter covers more than half the ground surface, bare soil is common, gravel and rocks are rare.

17. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
27.3	27.3	27.3	18.2	27.3	63.6	9.1				100.0

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	7.5	40.0	2.0		45.5	54.5	90.9	9.1	
Horizon 2	27.6	86.0	12.0	9.1	27.4	63.6	100.0		
Horizon 3	55.4	78.7	32.0		54.5	45.5	90.9		9.1

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	7.3	7.8	6.6	3.4	6.3	2.3	.4	.7	.2
Horizon 2	7.5	7.9	6.8	8.6	13.2	3.1	.5	1.6	.2
Horizon 3	7.7	8.4	7.0	9.7	18.7	4.7	7.8	2.0	.3

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	.8	45.5
Ceratoides lanata	.2	45.5
Artemisia cana	.3	27.3
Yucca glauca	.3	18.2
Chrysothamnus viscidiflorus	.2	18.2
Others (2 species)	.1	
Grasses and graminoids		
Bouteloua gracilis	20.0	100.0
Carex filifolia	17.3	100.0
Stipa comata	3.1	81.1
Agropyron smithii	1.1	72.7
Poa secunda	.1	45.5
Calamovilfa longifolia	.9	9.1
Others (4 species)	.3	
Forbs		
Artemisia frigida	.3	72.7
Gutierrezia sarothrae	.4	54.5
Commandra pallida	.4	45.5
Leptodactylon pungens	.5	27.3
Astragalus spatulatus	.2	36.4
Others (18 species)	1.0	
Total Herbaceous Vegetation	47.5	
Ground surface:		
Cryptograms	4.3	100.0
Litter	51.1	100.0
Bare soil	42.6	100.0
Gravel and rock	1.4	45.5

18. *Bouteloua gracilis* (BOGR) Sodgrass steppe (14 stands)

Bouteloua gracilis sodgrass steppe represents Great Plains shortgrass prairie in the Cheyenne River Basin. It is present on almost level uplands in all physiographic subregions except the Rochelle Hills Escarpment. Substrates are moderately deep, mainly medium-textured, and usually without stones in the upper portion of the solum. Stones may be present in the deeper horizons. Soil reaction ranges from medium acid at the surface to mildly alkaline in subsurface horizons where free calcium carbonates are present.

A few *Artemisia tridentata* shrubs are occasionally present; *Artemisia cana* is rare. Individual shrubs of both species are poorly developed and a shrub stratum is absent. The herb stratum is characterized by a dense cover of *Bouteloua gracilis*, which may form an uninterrupted sod several hectares in area. *Agropyron smithii* is usually present in this vegetation type, but is always less abundant than *Bouteloua gracilis*. *Poa secunda*, *Koeleria cristata*, and *Stipa comata* are widely distributed, less abundant grasses. *Bromus tectorum* forms dense stands in some locations. *Carex eleocharis* and *Carex filifolia* may be locally abundant. The absence of the latter species of sedge distinguishes this plant community type from *Bouteloua gracilis-Carex filifolia* steppe. The most important forb is *Opuntia polyacantha*. It occasionally forms serrated patches, especially where the *Bouteloua gracilis* sod is broken. Litter is very abundant; bare soil and stones are uncommon on the ground surface. Cryptograms are frequently present, but cover little of the ground surface.

18. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
28.6	21.4	21.4	28.6	50.0	28.6	14.3	7.1	28.6	14.3	57.1

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	5.1	14.0	2.0		78.6	21.4	78.6	7.1	14.3
Horizon 2	26.5	60.0	11.0		85.7	14.3	78.6	7.1	14.3
Horizon 3	51.7	100.0	19.0	21.4	64.3	14.3	64.3	21.4	14.3

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.1	7.4	5.4	3.9	11.0	1.5	.7	1.7	.3
Horizon 2	6.4	7.5	5.6	4.9	9.9	1.6	.9	2.2	.3
Horizon 3	6.8	7.9	5.9	6.5	14.6	.4	1.3	2.7	.1

Vegetation:	Coverage (%)	Constancy (%)
Shrubs		
Artemisia tridentata	3.5	50.0
Artemisia cana	.1	7.1
Grasses and graminoids		
Bouteloua gracilis	41.6	100.0
Agropyron smithii	13.5	85.7
Poa secunda	4.5	92.9
Stipa comata	2.7	85.7
Koeleria cristata	2.9	71.4
Bromus tectorum	9.6	14.3
Carex eleocharis	1.5	64.3
Carex filifolia	1.6	42.9
Festuca octoflora	.8	64.3
Others (7 species)	.8	
Forbs		
Opuntia polyacantha	3.1	57.1
Sphaeralcea coccinea	.9	100.0
Artemisia frigida	.9	57.1
Erigeron pumilis	.5	28.6
Agoseris glauca	.3	28.6
Others (18 species)	.1	
Total Herbaceous Vegetation	88.9	
Ground surface:		
Cryptograms	3.2	71.4
Litter	80.5	100.0
Bare soil	13.3	100.0
Gravel and rock	2.9	28.6

19. *Agropyron smithii* (AGSM) Sodgrass steppe (6 stands)

Agropyron smithii sodgrass steppe occurs on internal drainage basins with impeded soil permeability (playas) in the Rolling Divide physiographic subregion. Playas may be several hectares in area. Water from snow and high intensity rainfall in summer collects on the playas and may remain ponded for a week or more. The subsoil remains moist after the surface water evaporates and free water will be present below 2 m depth most of the summer. Stock ponds have been excavated in many playas to utilize this water. Consequently, the playa grassland is rather heavily grazed by livestock. The surface soil is generally medium-textured. Cracks develop when the surface dries. Greying and mottling is present in the subsoil.

Shrubs are absent. Grasses form a uniform cover over the entire playa. Coverage appears to be almost complete from a low, oblique angle, but grasses actually cover about two-thirds of the ground surface. *Agropyron smithii* is the characteristic species. It is present and frequently a characteristic species of several other rangeland vegetation types in the Cheyenne River Basin and is most abundant where soil moisture conditions are relatively mesic. Other grasses (*Poa secunda, Stipa comata, Koeleria cristata*) are erratically distributed, but can be locally abundant. The grass, *Hordeum jubatum*, and the forb, *Polygonum convolvulus*, grow only on banks of stock ponds. The spike-rush, *Eleocharis acicularis*, is an emergent in stock ponds. Litter cover is relatively high; about 30% of the ground surface is bare soil.

19. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
50.0	16.7	16.7	16.7	100.0				66.7	16.7	16.6

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizan 1	4.5	10.0	2.0	16.7	83.3		100.0		
Horizon 2	19.0	56.0	7.0	33.3	66.7		83.3	16.7	
Harizan 3	51.5	68.0	18.0	66.7	33.3		83.3	16.7	

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.1	7.2	5.1	4.9	8.6	3.5	.6	1.7	.3
Horizan 2	6.3	7.3	5.6	4.6	7.7	2.9	.8	1.7	.3
Harizan 3	6.8	7.5	6.1	6.4	9.1	3.8	1.2	2.8	.2

Vegetation:	Coverage (%)	Constancy (%)
Grasses and graminoids		
Agrapyran smithii	42.7	100.0
Paa secunda	7.3	50.0
Stipa camata	4.4	33.3
Koeleria cristata	2.3	50.0
Hardeum jubatum	6.4	16.7
Festuca actaflora	1.7	33.3
Eleocharis acicularis	2.1	16.7
Others (7 species)	.9	
Farbs		
Palyganum convolvulus	7.4	16.7
Achillea lanulasa	2.4	33.3
Taraxacum officinale	2.2	16.7
Vicia americana	.7	50.0
Franseria discolor	2.0	16.7
Artemisia ludaviciana	.6	33.3
Others (4 species)	2.1	
Tatal Herbaceaus Vegetation	85.2	
Graund surface:		
Cryptograms	1.1	33.3
Litter	62.1	100.0
Bare sail	29.5	100.0
Gravel and rock		

20. *Sarcobatus vermiculatus/Agropyron smithii-Bouteloua gracilis* (SAVE/AGSM BOGR) Shrub-steppe (5 stands)

Sarcobatus vermiculatus/Agropyron smithii-Bouteloua gracilis shrub-steppe is present on level to gently sloping, seasonally flooded, river benches in the lower Cheyenne River valley east of the Rochelle Hills Escarpment. Substrates are shallow, medium- to coarse-textured alluvium, with few stones. Relatively high levels of sodium are present in the subsoil in some locations. Surface soils are neutral or slightly acidic and salt crusts are absent.

Sarcobatus vermiculatus forms a well-defined shrub stratum of evenly distributed, relatively widely spaced individual shrubs, some of which exceed 1 m height. It is well-established and reproducing. This species is found in ecologically similar, mesic-saline habitats throughout the western rangelands. Some locations in the Cheyenne River Basin where it is abundant do not seem to have excessively saline substrates, however, *Artemisia tridentata* and *Artemisia cana* are occasionally present at low abundance.

Grasses are the prevalent life form in the herb stratum and provide almost complete coverage. *Agropyron smithii* and *Bouteloua gracilis* are characteristic. Both are abundant and ubiquitous. *Distichlis stricta* and *Sporobolus airoides* occur on more saline substrates. Few forb species are present. Only *Opuntia polyacantha* is common, but has erratic distribution. Mosses and lichens are abundant in this vegetation type and nearly a quarter of the ground surface is covered by cryptograms. Litter covers almost two-thirds of the ground surface; bare soil and stones almost 30%.

20. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
		60.0	40.0	80.0	20.0			100.0		

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	5.4	10.0	2.0		40.0	60.0	80.0		20.0
Horizon 2	17.0	23.0	8.0		60.0	45.0	100.0		
Horizon 3	29.0	38.0	18.0		100.0		80.0		20.0

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.4	7.0	5.6	1.2	2.7	.1	.9	1.6	.8
Horizon 2	6.9	8.0	6.4	2.4	5.9	.6	1.9	5.8	.3
Horizon 3	7.0	8.2	7.6	3.2	5.8	1.2	2.9	7.8	.3

Vegetation:

	Coverage (%)	Constancy (%)
Shrubs		
Sarcobatus vermiculatus	12.8	100.0
Artemisia tridentata	1.2	20.0
Artemisia cana	.2	20.0
Grasses and graminoids		
Agropyron smithii	27.8	100.0
Bouteloua gracilis	21.1	100.0
Distichlis stricta	14.2	60.0
Poa secunda	5.8	100.0
Festuca octoflora	5.6	80.0
Sporobolus airoides	6.3	40.0
Bromus tectorum	2.3	80.0
Sporobolus cryptandrus	1.2	30.0
Others (8 species)	.t	
Forbs		
Opuntia polyacantha	2.5	60.0
Draba reptans	.4	20.0
Artemisia frigida	.3	20.0
Others (4 species)	.2	
Total Herbaceous Vegetation	102.8	
Ground surface:		
Cryptograms	23.2	100.0
Litter	66.0	100.0
Bare soil	9.9	100.0
Gravel and rock	16.4	60.0

21. *Chrysothamnus viscidiflorus* (CHVI)
Shrub (3 stands)

Chrysothamnus viscidiflorus shrub occurs on level upper slopes and ridges in outcrops of badlands terrain in the Eastward-sloping Plain physiographic subregion of the Cheyenne River Basin. Substrates are deep, with medium soil textures and without coarse fragments. The surface horizon is thin, loose, porous, and strongly acidic. Subsurface horizons also have strongly acidic soil reaction. The calcium content of the substrate is high, but free calcium carbonates are not present. There also is a high content of magnesium in the substrate: the sodium content is low.

Chrysothamnus viscidiflorus forms an evenly distributed, open shrub stratum. The tallest shrubs are less than 5 dm; most are shorter. Crowns are compact and rounded. *Chrysothamnus nauseosus* and *Eriogonum pauciflorum* are the only other woody species. The latter is a prostrate half-shrub and is really a part of the herb stratum.

The herb stratum is species-poor; *Calamovilfa longifolia* is the only important species. It occurs in widely spaced clumps several meters across. *Calamovilfa longifolia* is most abundant in the Cheyenne River Basin where the substrate is sandy. The loose, porous surface soil may account for its presence in the badlands. Most of the ground surface is bare soil. Litter is not abundant. Cryptograms, gravel, and stones are absent.

21. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
100.0				100.0						100.0

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	2.3	4.0	1.0		100.0		100.0		
Horizon 2	35.0	48.0	17.0		100.0		100.0		
Horizon 3	72.3	80.0	62.0		100.0		100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	5.3	8.0	3.6	8.2	10.0	6.6	.2	.2	.2
Horizon 2	5.7	9.0	3.8	9.0	11.0	7.8	.2	.2	.2
Horizon 3	4.9	6.4	4.1	11.6	13.4	10.2	.3	.3	.3

Vegetation:

	Coverage (%)	Constancy (%)
Shrubs		
Chrysothamnus viscidiflorus	17.9	100.0
Chrysothamnus nauseosus	.3	33.3
Eriogonum pauciflorum	.1	33.3
Grasses and graminoids		
Calamovilfa longifolia	4.4	100.0
Agropyron smithii	.6	100.0
Oryzopsis hymenoides	.1	33.3
Forbs		
Thermopsis rhombifolia	.4	100.0
Vicia americana	.1	33.3
Total Herbaceous Vegetation	23.9	
Ground surface:		
Cryptograms		
Litter	21.3	100.0
Bare soil	77.5	100.0
Gravel and rock		

22. *Populus sargentii/Symphoricarpos occidentalis* (POSA/SYOC) Deciduous forest (8 stands)

Populus sargentii/Symphoricarpos occidentalis deciduous forest occurs on the floodplains of major rivers in the Cheyenne River Basin. These floodplains are both seasonally inundated and subirrigated. Substrates are alluvial and without genetic horizons. Depositional layering is present. Soil textures are mainly medium and coarse; soil reaction is neutral to slightly alkaline.

Populus sargentii forms open, linearly distributed, stands of mature trees. Boles often are over 6 dm basal diameter; heights exceed 15 m. The bole is usually less than one-third of total height, and branches are large and convoluted. Reproduction is rare and present only on recently bared river bars and cutbanks because seeds are able to germinate on this habitat. This habit accounts for the linear distribution of old trees.

Floodplains are important winter range for livestock. The characteristic shrub, *Symphoricarpos occidentalis*, is abundant where livestock are absent and may exceed 9 dm height. It is shorter, less abundant, and severely hedged where livestock are present. *Chrysothamnus nauseosus* increases in abundance on heavily grazed locations. *Artemisia cana* and *Rosa arkansana* are infrequently present shrubs. The latter is often heavily browsed. Many species are present in the herb stratum. *Agropyron smithii* is the most common grass. *Taraxacum officinale* and *Melilotus officinalis* are common forbs. Both are exotic and the result of overgrazing. *Smilacina stellata* is abundant only where grazing is absent. Litter covers almost all the ground surface.

22. Site Information

Surface:

Aspect of slope (Percent of stands)				Angle of slope (%) (Percent of stands)				Location on slope (Percent of stands)		
North	East	South	West	0–5	6–15	16–30	31–45	Low	Mid	Top
25.0	25.0	37.5	12.5	100.0				50.0	50.0	

Substrate:

	Thickness (Centimeters)			Texture (Percent of stands)			Coarse fragments (Percent of stands)		
	Avg	Max	Min	Fine	Med.	Coarse	None	Common	Abundant
Horizon 1	9.8	21.0	3.0	25.0	50.0	25.0	100.0		
Horizon 2	22.6	34.0	16.0	12.5	62.5	37.5	100.0		
Horizon 3	39.8	58.0	26.0		75.0	25.0	100.0		

	Reaction (pH)			Calcium (Percent)			Sodium (Percent)		
	Med	Max	Min	Avg	Max	Min	Avg	Max	Min
Horizon 1	6.9	7.6	6.1	5.8	10.6	2.0	.4	.6	.2
Horizon 2	6.8	7.5	6.2	5.6	8.4	2.8	.4	1.0	.1
Horizon 3	7.0	7.8	6.4	6.2	9.1	2.1	.4	.6	.2

Vegetation:

	Density (n/acre)	Constancy (%)
Trees		
Populus sargentii	4.1	100.0
	Coverage (%)	Constancy (%)
Shrubs		
Symphoricarpos occidentalis	11.7	100.0
Chrysothamnus nauseosus	6.2	25.0
Artemisia cana	.3	12.5
Rosa arkansana	.1	12.5
Grasses and graminoids		
Agropyron smithii	3.5	100.0
Poa secunda	5.4	87.5
Stipa comata	1.2	50.0
Stipa viridula	1.5	37.5
Agropyron spicatum	.7	37.5
Calamovilfa longifolia	.5	50.0
Others (12 species)	2.8	
Forbs		
Taraxacum officinale	2.8	87.5
Melilotus officinalis	1.0	87.5
Solidago missouriensis	2.1	37.5
Smilicina stellata	2.1	25.0
Haplopappus acaulis	1.3	37.5
Artemisia ludoviciana	.7	62.5
Artemisia frigida	.2	25.0
Others (7 species)	1.4	
Total Herbaceous Vegetation	45.5	
Ground surface:		
Cryptograms	.2	37.5
Litter	97.2	100.0
Bare soil	1.1	87.5
Gravel and rock	.1	12.5

Appendix B: Ranked List of the Vascular Plants Species Found in the 22 Vegetation Types

Harrington (1954) was the authority used for trees, shrubs, forbs, and graminoids; Hitchcock (1950) for grasses. Specimens are on file at the U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory. Laramie, Wyoming.

The numeral in () indicates the number of vegetation types in which this species occurs as a characteristic or subordinate species. The term 'Other' species are listed alphabetically by genus and species within the genus. Taxonomic names of 'other' species do not appear in tables.

Since this study was completed the names have been changed for the following species: *Agropyron smithii* = *Pascopyrum smithii*, *Agropyron trachycaulum* = *Elymus trachycalus*, *Festuca octoflora* = *Vulpia octoflora*

Trees
- Characteristic or subordinate.
  - *Pinus ponderosa* Dougl. ex Lawson (4)
  - *Juniperus scopulorum* Sarg. (4)
  - *Populus sargentii* Dode. ex Mon. (1)

Shrubs
- Characteristic or subordinate
  - *Artemisia tridentata* Nutt. (18)
  - *Artemisia cana* Pursh (8)
  - *Yucca glauca* Nutt. (6)
  - *Chrysothamnus viscidiflorus* (Hook.) Nutt. (5)
  - *Atriplex canescens* (Pursh) Nutt. (2)
  - *Artemisia pedatifida* Nutt. (1)
  - *Rhus trilobata* Nutt. ex T. & G. (1)
  - *Sarcobatus vermiculatus* (Hook.) Torr. (1)
  - *Symphoricarpos occidentalis* Hook. (1)
- Subordinate only
  - *Eriogonum pauciflorum* Pursh (6)
  - *Chrysothamnus nauseosus* (Pallas) Britt. (4)
  - *Eriogonum ovalifolium* Nutt. (3)
  - *Atriplex gardneri* (Moq.) D. Dietr. (2)
  - *Ceratoides lanata* (Pursh) J. T. Powell (2)
  - *Ribes inebrians* Lindl. (2)
  - *Eriogonum brevicaule* Nutt. (1)
  - *Prunus virginiana* L. (1)
  - *Rosa arkansana* Porter (1)

Grasses
- Characteristic or subordinate
  - *Bouteloua gracilis* (H. B. K.) Lag. ex Steud (16)
  - *Agropyron smithii* Rydb. (14)
  - *Stipa comata* Trin. & Rupr. (12)
  - *Agropyron spicatum* (Pursh) Scribn. & Smith (10)
  - *Calamovilfa longifolia* (Hook.) Scribn. (6)
  - *Schizachyrium scoparium* Michx. (3)
  - *Stipa viridula* Trin. (3)
- Subordinate only
  - *Poa secunda* Presl. (16)
  - *Koeleria cristata* (L.) Pers. (12)
  - *Bromus tectorum* L. (7)
  - *Festuca octoflora* Walt. (4)
  - *Oryzopsis hymenoides* (Roem. & Schult.) Richter (4)
  - *Aristida longiseta* Steud. (3)
  - *Agropyron desertorum* (Fisch.) Schult. (1)
  - *Distichlis stricta* (Torr.) Rydb. (1)
  - *Hordeum jubatum* L. (1)
  - *Poa annua* L. (1)
  - *Sitanion hystrix* (Nutt.) J. G. Smith (1)
  - *Sporobolus airoides* (Torr.) Torr. (1)
  - *Sporobolus cryptandrus* (Torr.) A. Gray (1)
- Other only
  - *Agropyron trachycaulun* (Link) Malte
  - *Agrostis exarata* Trin.
  - *Bromus inermis* Leyss.
  - *Bromus japonicus* Thunb.
  - *Elymus canadensis* L.
  - *Muhlenbergia cuspidata* (Torr.) Rydb.
  - *Oryzopsis micrantha* (Trin. & Rupr.) Thurb.
  - *Phleum pratense* L.
  - *Poa ampla* Merr.
  - *Poa canbyi* (Scribn.) Piper
  - *Sitanion longifolium* J. G. Smith
  - *Stipa spartea* Trin.

Graminoids
- Characteristic or subordinate
  - *Carex filifolia* Nutt. (11)
- Subordinate only
  - *Carex heliophila* Mack. (2)

Carex eleocharis Bailey (1)
Eleocharis acicularis (L.) R. & S. (1)
Other only
Carex brevipes W. Boott.

Forbs
Subordinate only
Artemisia frigida Willd. (18)
Gutierrezia sarothrae (Pursh) Britt. & Rushby (8)
Sphaeralcea coccinea (Pursh) Rydb. (8)
Arenaria hookeri Nutt.ex T. & G. (7)
Opuntia polycantha Haw. (6)
Vicia americana Muhl. (6)
Achillea lanulosa Nutt. (5)
Leptodactylon pungens Nutt. ex Rydb. (5)
Commandra pallida DC. (4)
Artemisia ludoviciana Nutt. (3)
Astragalus spatulatus Sheld. (3)
Cerastium arvense L. (3)
Cymopteris acaulis (Pursh) Raf. (3)
Heterotheca villosa (Pursh) Shinners (3)
Phlox hoodii Rich. (3)
Psoralea argophylla Pursh (3)
Taraxacum officinale Weber (3)
Dalea compacta Spreng. (2)
Draba reptans (Lam.) Fern. (2)
Gaura coccinea (Nutt.) Pursh (2)
Lomatium foeniculaceum (Nutt.) Coult. & Rose (2)
Thermopsis rhombifolia (Nutt.) Richards. (2)
Agoseris glauca (Pursh) D. Dietr. (1)
Astragalus aborginum Rich. (1)
Astragalus crassicarpus Nutt. (1)
Atriplex dioeca (Nutt.) Macbride (1)
Cirsium undulatum (Nutt.) Spreng. (1)
Cryptandra bradburyiana Payson (1)
Dalea purpurea Vent. (1)
Erigeron pumilus Nutt. (1)
Haplopappus acaulis (Nutt.) Gray (1)
Leucocrinum montanum Nutt. (1)
Liatris punctata Hook. (1)
Lupinus pusillus Pursh (1)
Melilotus officinalis (L.) Pallas (1)
Polygonum convolvulus L. (1)
Smilicina stellata (L.) Desf. (1)
Solidago missouriensis Nutt. (1)
Other only
Abronia fragrans Nutt.
Allium textile A. Nels. & Macbr.
Antennaria dimorpha (Nutt.) T. & G.
Antennaria rosea (D.C. Eaton) Greene
Arenaria fendleri A. Gray
Artemisia dracunculus L.
Asclepias viridiflora Raf.
Aster fendleri A. Gray
Astragalus adsurgens Hook.
Astragalus bisulcatus (Hook.) Gray
Atriplex argentea Nutt.
Besseya cinera (Raf.) Pennell
Camelina microcarpa Andrz. in DC.
Campanula rotundifolia L.
Chaenactis douglasii (Hook.) Hook. & Arn.
Chenopodium album L.
Chenopodium atrovirens Rydb.
Cirsium flodmanii (Rydb.) Arthur
Collinsia parviflora Dougl. ex Lindl.
Collomia linearis Nutt.
Coryphanta vivipara (Nutt.) Britt. & Rose
Draba nemorosa L.
Draba oligosperma Hook.
Equisetum arvense L.
Erigeron compositus Pursh
Erigeron engelmanni A. Nels.
Franseria discolor Nutt.
Grindelia squarrosa (Pursh) Dunal
Haplopappus multicaulis (Nutt.) Gray
Haplopappus spinulosus (Pursh) DC.
Hedeoma hispida Pursh
Helianthus annuus L.
Helianthus petiolaris Nutt.
Hymenopappus filifolius Hook.
Lappula redowskii (Hornem.) Greene
Lepidium densiflorum Schrad.
Lesquerella alpina (Nutt.) Wats.
Lesquerella gracilis (Hook.) S. Wats.
Lesquerella ludoviciana (Nutt.) Wats.
Lewisia rediviva Pursh
Linum lewisii Pursh
Linum rigidum Pursh
Lithospermum ruderale Dougl.
Lupinus argenteus Pursh
Lupinus caudatus Kellogg
Lygodesmia juncea (Pursh) D. Don
Machaeranthera grindelioides (Nutt.) Cronq.
Machaeranthera tanacetifolius (H. B. K.) Nees
Madia glomerata Hook.
Melilotus alba Medic.
Mentzelia disperma Wats.
Microseris nutans (Hook.) Schultes-Bip.
Microsteris gracilis (Hook.) Greene
Monolepis nuttalliana (Schultes) Engelm.
Oenothera albicaulis Pursh
Orobanche fasciculata Nutt.

Oxytropis lambertii Pursh
Penstemon albicus Nutt.
Penstemon eriantherus Pursh
Penstemon glaber Pursh
Phacelia hastata Dougl. ex Lehm.
Phacelia linearis (Pursh) Holz.
Picradeniopsis oppositifolia (Nutt.) Rydb.
Plagiobothrys scouleri (Hook. & Arn.) I. M. Johnson
Plantago patagonica Jacq.
Potentilla hippiana Lehm.
Psoralea hypogaea Nutt.
Psoralea tenuiflora Pursh
Pulsatilla patens L.
Ratibida columnifera (Nutt.) Woot. & Standl.
Rudbeckia hirta L.
Rumex venosus Pursh
Salsola kali L.
Senecio fendleri Gray
Sidalcea candida Gray
Sisymbrium altissimum L.
Stephanomera tenuifolia (Torr.) Hall
Tradescantia occidentalis (Britt.) Smyth
Tragopogon dubius Scop.
Trifolium microcephalum Pursh
Trifolium repens L
Veronica peregrina L.
Woodsia oregana D.C. Eaton
Xylorrhiza glabriuscula Nutt.
Zigadenus venenosus Wats.

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Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota

*Station Headquarters: 240 W. Prospect Rd., Fort Collins, CO 80526